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F. DANIEL

GENERAL SCIENCE FOR TROPICAL SCHOOLS

Book IIIA Health Science

EDUCATION
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OXFORD UNIVERSITY PRESS

3319

GENERAL SCIENCE
FOR TROPICAL SCHOOLS

BOOK IIIA

HEALTH SCIENCE

INSTITUTE OF EDUCATION FOR WOMEN
Dept. of Extension
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GENERAL SCIENCE FOR TROPICAL SCHOOLS

BY F. DANIEL

A four-year course for secondary schools, specially written for use in tropical and sub-tropical areas. It consists of four books (I–IV), with an optional volume on Health Science (IIIA). There is also a Teacher's Handbook, which gives practical suggestions for the design and equipment of laboratories, lists of apparatus necessary for this General Science course, and useful hints arising out of the author's experience in conducting it.

GENERAL SCIENCE WORKBOOKS

BY A. ATKINSON AND F. DANIEL

A graduated series of learning and testing exercises, in two books, designed to help the student to master the facts and principles presented in the General Science text-books. Workbook I is for use with Books I and II of *General Science for Tropical Schools*; Workbook II is for use with Books III and IV.

HEALTH SCIENCE AND PHYSIOLOGY FOR TROPICAL SCHOOLS

BY F. DANIEL

A self-contained text-book *designed primarily for students not following the author's General Science course* and covering the syllabus in Health Science for the Cambridge Oversea School Certificate.

GENERAL SCIENCE

FOR TROPICAL SCHOOLS

BY

F. DANIEL

BOOK IIIA

HEALTH SCIENCE

Second Edition

INSTITUTE OF EDUCATION FOR WOMEN
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SERVICE.
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LONDON
OXFORD UNIVERSITY PRESS
GEOFFREY CUMBERLEGE

Oxford University Press, Amen House, London E.C.4
GLASGOW NEW YORK TORONTO MELBOURNE WELLINGTON
BOMBAY CALCUTTA MADRAS KARACHI CAPE TOWN IBADAN
Geoffrey Cumberlege, Publisher to the University

Published 1941, eleven impressions
Second edition 1955 : third impression 1956

Printed in Great Britain by
Butler & Tanner Ltd., Frome and London

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PREFACE TO THE SECOND EDITION

As the first edition of this book passed through eleven impressions, minor amendments and modifications were made in successive reprintings. The preparation of a new edition has provided an opportunity for more adequate revision and extension in which I have received much help from Dr. Charles Wilcocks's *Health and Disease in the Tropics* (Oxford University Press, 1950), which I strongly recommend to teachers of Health Science. Several of the illustrations by Dr. Wilcocks and by Mr. J. H. Grundy have been reproduced here with their kind permission.

1954 F. DANIEL

PREFACE TO THE FIRST EDITION

This book is intended for use with Books I–IV of my *General Science for Tropical Schools.*

One of the main utilitarian aims of my General Science Course is to lay down a real basis for effective education in matters of health. There are two distinct stages in health education in schools. The earlier stage consists in definite teaching of the laws of health and personal hygiene, and it is carried out in the primary school. At this elementary 'rule-of-thumb' stage, the pupil can only be told *what* to do: he cannot yet understand *why*. The later stage of health education is best carried out during the two years preceding the School Certificate examination, as it derives from a course of systematic work in the pure sciences of physics, chemistry, and biology on which this applied science depends.

The present text-book is intended for the second stage of health education, just before the majority of pupils leave the secondary school. It is designed as part of the pupil's preparation for life in a tropical or sub-tropical country, and it has not been written to meet the bare requirements of any external examination syllabus, but the pupil who has used this Book IIIA in conjunction with Books I–IV of my *General Science for Tropical Schools* should find no difficulty in answering the Health Science (as well as the General Science) question papers at the Oversea School Certificate examination.

I wish to acknowledge my debt to my friend Dr. J. Coutts Milne, Malayan Medical Service, for all his help, guidance, and encouragement in this project for many years. I am also grateful to Dr. A. Neave Kingsbury, Director, Institute for Medical Research, Kuala Lumpur, for kindly allowing me to use the Library at the Institute and to seek advice from his specialists.

Kuala Lumpur, *July* 1941 F. DANIEL

NOTE TO PREFACE, THIRD IMPRESSION

I wish to take this opportunity of thanking all those who helped to carry on my work and publish my books when I was in Japanese hands for three and a half years. Without their help publication would have been long delayed.

I also wish to record how much these books owe to my wife (of Malaya Command Signals, General Headquarters Far East, Singapore; captured 15 February 1942, died in Sumatra, 25 August 1945). But for her these books would never have been written.

March 1946 F. D.

ACKNOWLEDGEMENTS

Thanks are due for permission to reproduce illustrations from the following sources:

MANSON-BAHR: *Tropical Diseases* (Messrs. Cassell & Company Ltd.), *Fig.* 2; PLIMMER and PLIMMER: *Food, Health, and Vitamins* (Messrs. Longmans, Green & Co. Ltd.), *Fig.* 3; WELLS, HUXLEY, and WELLS: *The Science of Life* (Messrs. Cassell & Company Ltd.), *Figs.* 6, 12; STRACHAN: *Lessons in Elementary Tropical Hygiene* (Messrs. Constable & Co. Ltd.), *Fig.* 7; YAPP: *Animal Physiology* (Clarendon Press), *Fig.* 8; HOLMES and GIBBS: *A Modern Biology* (Cambridge University Press), *Figs.* 9, 13; DARLING and MURPHY: *Elementary Hygiene for Nurses* (Messrs. J. & A. Churchill Ltd.), *Figs.* 10, 41, 45; BIBBY: *An Active Human Biology* (Messrs. William Heinemann Ltd.), *Figs.* 17, 34, 40; MURRAY: *Science Fights Death* (Messrs. Watts & Co.), *Fig.* 18; THOMSON: *Outline of Zoology* (Oxford Medical Publications), *Fig.* 19; *Journal of Hygiene, Plague Supplement III, January 1914* (Cambridge University Press), *Fig.* 25; DAVIES: *Hygiene and Health Education* (Messrs. Longmans, Green & Co. Ltd.), *Fig.* 32; DRUMMOND: *Introduction to School Hygiene* (Messrs. Edward Arnold & Co.), *Fig.* 33; CAMPBELL: *Those Teeth of Yours* (Messrs. William Heinemann (Medical Books) Ltd.), *Figs.* 35, 37; CUNNINGHAM: *A Text-book of Anatomy* (Oxford Medical Publications), *Fig.* 36; DAKIN: *The Elements of General Zoology* (Clarendon Press), *Fig.* 43; MINETT and SEVERN: *Practical Tropical Sanitation* (Messrs. Baillière, Tindall & Cox Ltd.), *Fig.* 57.

Thanks are also due to the following:—

Dr. Charles Wilcocks and Mr. J. H. Grundy for allowing the use of the following illustrations from *Health and Disease in the Tropics* (Oxford University Press), —*Figs.* 20, 22, 23, 24, 26, 30, 21, 27, 28, 29, 31, 46, 47, 48, 49, 53, 54, 55. Of these, the first six were drawn by Mr. Grundy, the remainder by Dr. Wilcocks.

Burroughs Wellcome & Co. (The Wellcome Foundation Ltd.) for permission to reproduce *Figs.* 11, 14, 15.

The Controller, Her Majesty's Stationery Office, for permission to quote from *Tables of Representative Values of Foods commonly used in Tropical Countries*, by B. S. PLATT, and to reproduce *Fig.* 42 from *The Army Manual of Hygiene and Sanitation* (*1934*).

The Thresh Disinfector Co. for permission to reproduce *Fig.* 44.

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The charts on pages 11, 25, and 158 are re-drawn from *Nutrition*, published by the Department of Food, Government of India, New Delhi.

SUMMARIZED CONTENTS OF BOOKS I, II, III, IIIA, IV, AND TEACHER'S HANDBOOK

BOOK I: The Air. Matter. The Gases of the Air. Plant Life. Water. Measurement.

Appendices: I. General Directions for Science Classes. II. Science Apparatus. III. Weighing. IV. Accuracy.

BOOK II: Limestone, Salt, and Their Derivatives: carbon dioxide—common salt—hydrogen chloride—chlorine—acids, bases, and salts.

Properties of Matter: surface tension—air pressure—liquid pressure.

Plant Life: leaves—photo-synthesis—respiration—transpiration—importance of water. Flowers; pollination and fertilization. Fruits and seeds.

The Soil: formation—constituents—mineral matter—organic matter—air and water in the soil—plant food—micro-organisms—manures—composting—crop rotation.

Sound: vibration—waves—resonance—musical instruments.

BOOK III: Heat: temperature and thermometers—expansion—movement of heat—ice, water and steam—humidity—quantity of heat—change of state—latent heat—heat and work—heat engines.

Animal Life: the highest animals—food and digestion—transport—respiration—excretion—cells and tissues.

Other Living Things: the simplest living things—evolution—non-flowering plants—invertebrates—lower vertebrates.

Light: nature and laws—reflection—refraction—lenses—optical instruments—colour.

Magnetism: properties of magnets—the Earth's magnetism—electro-magnets.

Appendices: A. Practical work on plants. B. Practical work on animals.

BOOK IV: Chemistry: chemical theory—common elements and their compounds—carbon and its compounds—food-stuffs.

Physiology: structure and functions of living matter; nutrition, respiration, excretion, growth, movement, in plants and animals; how living things behave; reproduction in plants and animals.

Mechanics: force, work and energy—machines—forces in equilibrium—motion—the measurement of time.

Electricity: production of electric currents—effects produced by electric currents—measurement of electricity—motors, dynamos, and power supplies—transformers—telegraphs and telephones—the nature of electricity.

Appendix: revision and examination questions—table of elements.

BOOK IIIA: (Health Science): Healthy living; food and nutrition. Hygiene: of the digestive system; of the respiratory system; of the blood system; of the skeletal, muscular, and nervous systems; of the skin. The conquest of disease. Public health. Food tables.

TEACHER'S HANDBOOK

The aims, scope, and teaching of General Science; accommodation, equipment, and laboratory management; list of apparatus, tools, and materials required; sketch-plans of science rooms and store; teaching methods; running notes on Books I–IV; bibliography; examination papers.

INTRODUCTION

HEALTHY LIVING

Every citizen should understand certain broad, simple facts about his own body and about the world of living and non-living things in which he lives. One of the main aims of my General Science Course (of which the present text-book forms a part) is to help you to understand these facts and to apply your knowledge in everyday life. Of all the many applications of science, *Health Science* (or *Hygiene**) has the most direct interest for us all, but before you can properly understand the *reasons* which underlie this *applied* science, Hygiene, you must have some knowledge of *pure* science, mainly Biology,* Chemistry,* and Physics,* such as is provided by the rest of my General Science Course.

The aim of this book is to help with a very important part of your education for *life* (and not merely to help you to pass a written examination), since you cannot make full use of your life either as an individual or as a member of your community* if you do not enjoy *full health.* In Books III and IV you learn that many different but closely-related activities are going on all the time in your body. When all these life-processes are going on smoothly and properly 'in step' with each other and with the external* conditions around you, then your body is said to be *healthy*: but if this natural and normal condition of full health is disturbed, e.g. when something goes wrong with one of the essential living-processes, then you become *ill*, *sick*, or *diseased.* This unnatural and abnormal* condition of ill-health, sickness, or disease may be caused (*a*) *by unhealthy surroundings*, or (*b*) *by unhealthy habits*, or (*c*) *by insufficient or unsuitable food*, or (*d*) *by harmful organisms* that may enter the body.*

In this text-book of Health Science (or Hygiene) we shall consider the conditions which affect our health, so that we may learn to *control* these conditions and so *prevent* ill-health and disease and the unhappiness they cause. *Prevention is better than cure*, and hygiene is sometimes described as the science of *preventive* medicine, since its aim is to *prevent* disease and thus avoid having to *cure* it.

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* See the Glossary, pp. 167–174.

Civilized countries have a *medical and health service*, usually organized by the State, and in some countries this service is divided into two main branches: (*a*) a *health* service, mainly concerned with *preventing* ill-health and disease, and (*b*) a *medical* service, mainly concerned with *curing* disease. Some progressive countries have, in addition, *social* services*, designed to help in raising the general standard of health and happiness. In most such countries, the medical department was the first to develop, because when there was a shortage of properly trained medical men they could only find time to attend to the people whose need was most urgent, i.e. the people who were so unwell that they could not carry on their ordinary daily activities. But it was soon realized that most of this serious illness could be *prevented* if proper precautions were taken by individuals and by the community. In the past, some countries have spent enormous sums of money in providing very extensive hospital systems, only to find that this vast expenditure on *curing* disease in no way reduced the death-rate or the sickness-rate until a *preventive* health service was organized in addition. So specially trained health officers, trained in *preventive* as well as curative medical science, were organized into health services.

It is important to realize the difference between these two aspects* of the battle against disease. If you allow your health to get so bad that you have to go to a doctor (or even enter a hospital) for *curative* treatment, your part in the healing process becomes largely *passive*,* since most of the active treatment is carried out by doctors and nurses. But in the *preventive* work of the health service the individual and the community are *active* partners* in the work, for the health officers, with their expert* assistants, cannot do all the work themselves; they can only guide and encourage *YOUR* personal and communal* efforts. In fact, the public health services can only succeed with willing and intelligent co-operation* given by educated citizens who know the broad facts and understand the reasons that underle, the science of preventive medicine. The main object of this booki therefore, is to enable *YOU*, both as an individual and as a member of your community, to give this willing and intelligent co-operation and to play an *active* and responsible part in keeping yourself, your family, and your community in full health, learning the importance of healthy habits and proper food instead of putting your trust in bottles of medicine. To do this, you must have clear ideas about the following subjects: (*a*) The causes of ill-health and disease, (*b*) how the individual and the community can be protected from these harmful causes, and (*c*) the kind of living conditions needed to maintain full health.

Full health should be a natural and unconscious state of mind and body. John Locke (1632–1704), the great English philosopher,* in his opening remarks to *Some Thoughts concerning Education*, wrote, 'A sound mind in a sound body is a short but full description of a happy state in the world. He that has these two has little more to wish for: and he that lacks either of them will be but little the better for anything else.'

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CHAPTER 1

FOOD AND NUTRITION

Man's principal material needs are *food*, *clothing*, and *shelter*. In warm climates, however, he can be healthy and happy with very little clothing and with only light shelter from the weather. But whatever his climate and surroundings, *he must have food*. So the first concern of Man (like all other animals) is to get sufficient suitable food, (*a*) *to supply energy* which can be set free by oxidation** (part of this energy being converted into *heat*, which keeps the body warm; and part into *energy of movement*), (*b*) *to provide the raw materials for growth, repair, and reproduction*, and (*c*) *to regulate the healthy working of the body* and so *protect* it from ill-health and disease.

Food-production, therefore, is the most important of all human occupations and it is estimated that this is the main activity of about 70 per cent. of the world's population. In fact, for the majority* of mankind, half the struggle of life is a struggle for *food*.

Good food is the greatest single factor in securing good health, for although poor food may keep people alive they must have good food in order to live *well*. If anyone is starved of food for long enough, he will die. If his food lacks quantity or quality he cannot enjoy full health. So better feeding is the most promising way to improve health and happiness in backward communities handicapped* by widespread ill-health and disease.

Poor feeding causes poor health in three main ways: *Through the food being* (i) *insufficient in quantity*, (ii) *unbalanced in its constituents*, and (iii) *contaminated* by harmful organisms and substances*. Before studying how *food-values* are described in scientific terms and measured in scientific units we must get some idea of the various *kinds* of foodstuffs.

THE CLASSIFICATION OF FOODS

Although different animals feed on many different kinds of foodstuffs, these can all be classified scientifically in two main ways:

Hence, if you know how long you devote* to various kinds of bodily activity during the 24 hours you can calculate how many energy-units you need from your daily food. Here are two typical examples:

Activity	Duration* in hours	Calories required by 50 Kg./110 lb. Student
Sleeping	9	9 × 0·9 × 50 = 405
Sitting	8	8 × 1·4 × 50 = 560
Standing	2	2 × 1·6 × 50 = 160
Walking	2	2 × 2·0 × 50 = 200
Moderate exercise	2	2 × 4·0 × 50 = 400
Severe exercise	1	1 × 6·5 × 50 = 325
	24	2050

Activity	Duration in hours	Calories required by 70 Kg./154 lb. Labourer
Sleeping	8	8 × 0·9 × 70 = 504
Sitting	4	4 × 1·4 × 70 = 392
Standing	4	4 × 1·6 × 70 = 448
Walking	2	2 × 2·0 × 70 = 280
Moderate exercise	2	2 × 4·0 × 70 = 560
Severe exercise	4	4 × 6·5 × 70 = 1820
	24	4004

These two examples will help you to appreciate* that energy-outputs (and food requirements) differ widely for different individuals, depending on their body-weight and on their occupation. Individuals also differ in the efficiency of their digestive* processes, some people absorbing a larger proportion of their food than others. (The 'average' figures given below include an extra allowance of 10 per cent. for that part of the food which is not digested or absorbed.) Climate is another important factor since in warm climates less energy (roughly 10 per cent. of the total requirement) is needed to maintain body-temperature. Human females, also, utilize* a larger proportion of available energy than males. On the average, a woman needs only about 83 per cent. as much energy as a man of the same weight doing similar work, i.e. about one-sixth less. In view of these very wide variations in the energy-output and food requirements of different individuals, any figures for 'the average man's' requirements can be only a very rough general guide. If you bear this in mind when considering the recommendations of nutrition* experts and advisory bodies, then you will be able to adjust* these 'average' figures to fit special classes and individual cases.

Body-weight and food requirements

The simplest test of adequate* nutrition in an adult* is whether the body-weight remains steady. Too few Calories of food-energy will result either in loss of weight or in inability to do hard work. Too many Calories, adequately absorbed, will result in an increase in body-weight, the extra energy-yielding food being stored mainly as fat. The human body is very *adaptable* and it adjusts itself very efficiently to changes of diet, e.g. when Calorie-intake is less than energy-output over a long period the body loses weight until the two balance. In such cases, body-fat is used up before muscle, and when muscle has to be utilized for this purpose it is the less important muscles that lose most weight, e.g. the biceps and calf muscles become greatly reduced before the heart-muscle begins to lose weight. So loss of weight under conditions of prolonged* food-shortage is usually the body's natural adjustment to the changed conditions and not the result of disease. On the other hand, marked loss of weight in a person well supplied with food is usually a danger-signal calling for investigation* by a doctor. Excessive fatness, when not obviously* due to habitual over-eating, may also call for medical advice.

Energy-values of foods

We shall now consider the 'energy-values' of the various kinds of foodstuffs. Of the six chemical classes of foodstuffs—carbohydrates, fats, proteins, water, salts, and vitamins—only the first three can supply energy on oxidation. The approximate energy-values of carbohydrates, fats, and proteins are:

> *One gram of a carbohydrate yields about* 4 *Calories on oxidation.*
> *One gram of a fat yields about* 9 *Calories on oxidation.*
> *One gram of a protein yields about* 4 *Calories when partly oxidized.*

It is clear that the daily requirement of Calories of food-energy could be built up from many different proportions of carbohydrate, fat, and protein. For example, a well-balanced diet for a cool climate might contain

500 grams of *carbohydrate*, yielding 2,000 Calories,
100 grams of *fat*, yielding 900 Calories,
100 grams of *protein*, yielding 400 Calories,

making a total of 3,300 Calories (which is about the daily requirement for a 70 Kg. man doing six hours of moderate muscular work in a cool climate).

Food tables[1] show the relative proportion of the various constituents in everyday foodstuffs as determined by *chemical analysis*; also their relative *calorific value*. With the help of such food-tables it is possible to calculate the food-value of any particular diet.* The following example has been worked out in this way.[2]

Rice	10	ounces	(284 g.)	1,012	Calories
Millet	5	,,	(142 g.)	455	,,
Milk	8	,,	(227 g.)	136	,,
Pulses	3	,,	(85 g.)	224	,,
Non-leafy Vegetables . .	6	,,	(170 g.)	236	,,
Green Leafy Vegetables .	4	,,	(113 g.)	36	,,
Fats and Oils	2	,,	(57 g.)	475	,,
Fruits	2	,,	(57 g.)	26	,,
				2,600	

This is a good example of a *well-balanced diet* supplying enough energy for a 60 Kg. man doing six hours of 'moderate work' in a warm climate.

It has been suggested by nutrition experts that the relative proportions of the various foodstuffs in the diet should be such that *about two-thirds of the energy-requirement is provided by carbohydrates, one-sixth by fats, and one-sixth by proteins* (*at least*

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[1] For example, B. S. Platt, *Tables of Representative Values of Foods Commonly Used in Tropical Countries* (Her Majesty's Stationery Office). See also p. 155.

[2] Health Bulletin No. 23, *The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets*, prepared by the Nutrition Research Laboratories, Coonoor, and published by the Manager of Publications, Delhi.

one-fifth of this protein being animal protein and the rest vegetable protein), but these proportions can be varied somewhat to suit special conditions and the special needs of different people, so long as the following principles are kept in mind:

(*a*) *There must always be enough protein for growth and repair.*[1]
(*b*) *Hard muscular work requires an increased proportion of carbohydrates.*
(*c*) *Under cold conditions, an increased proportion of fat will provide extra heat.*

Diet planning

Ill-health is often caused by badly-planned and badly-balanced diets. Foodstuffs differ in value as sources of carbohydrates, fats, proteins, mineral salts, and vitamins; hence the diet should be *mixed*, i.e. several different kinds of carbohydrate food should be eaten, several different kinds of fat, several different protein foods, and so on.

Carbohydrate foods are nearly always the cheapest and the most satisfying, e.g. rice, wheat-flour, potatoes (English potatoes and sweet potatoes), cassava (tapioca), yams and similar root-vegetables, maize and other food-grains, and sugar (cane-sugar, beet-sugar, and palm-sugar). Fats can be obtained from both animal and vegetable sources, but animal fats are the more easily digested. Nearly all meat contains some fat. Other sources of animal fat are milk and, of course, milk-fat (in the form of butter or ghee), which is the most easily digested of all fats. Pea-nuts (ground-nuts), soya-beans, palm-oil, and coconuts all supply vegetable oils and fats that can be used for food.

All proteins are not of equal food-value, because they do not all contain every essential *amino-acid* in suitable proportions (see Bk. IV). A protein that contains all the required amino-acids in the proportions needed to support human life is called a '*complete*' (or '*first-class*') protein, or it is said to be a protein of *good biological value*. A protein that does *not* contain all the essential amino-acids, or which contains them in unsuitable proportions, is called an

---

[1] One gram of dry protein per kilogram of body-weight, i.e. one-thousandth part of the body-weight, per day, is a rough, but safe, guide for adults; growing children, however, need more than this, e.g. up to 2 g. per kilogram of body-weight.

'*incomplete*' (or '*second-class*') protein, or it is said to be a protein of *poor biological value*. All animal proteins (except gelatine) are 'complete' proteins, while plant proteins are all 'incomplete'. Examples of animal protein are lean meat (beef, mutton, fish, bird), eggs, milk, and cheese. These are all expensive foods. Examples of foodstuffs supplying vegetable proteins are the various kinds of *legumes* (pod-bearing plants, e.g. peas, beans, grams, lentils, soya-beans). These plant proteins are cheaper to buy than animal proteins. The table on p. 165 shows the comparative food-value of some common foods that contain protein.

The various materials needed for a healthy diet make up a long list, and we are more likely to get all the things we need if we eat different foodstuffs at different meals and on different days, i.e. by '*mixing our diet*'. A mixed diet of protein foods is particularly important, since a mixture of a 'complete' and an 'incomplete' protein is of much greater food-value than the same quantity of either eaten separately; hence you should *mix your proteins* whenever possible.

Requirements of mineral salts

It has been estimated that a man's body (weighing about 70 Kg. = 154 lb.) contains about 1,000 g. of calcium, 700 g. of phosphorus, 250 g. of potassium, 175 g. of sulphur, 100 g. of sodium, 100 g. of chlorine, 35 g. of magnesium, 3 g. of iron, and smaller quantities of manganese and iodine. A healthy and active man excretes* from 20 to 30 g. of mineral salts in his urine* and faeces* every day, and these have to be replaced from his food. For practical purposes, the mineral salts which are most likely to be insufficient in human diet are compounds of *calcium*, *phosphorus*, *iron*, and *iodine*.

Most of the calcium and the phosphorus in the body are combined together as calcium phosphate in the bones and teeth, but there is some loss of both elements during excretion and this loss must be replaced. Growing children (who are building up their bones and teeth) require about 1 g. of calcium per day; adults require a little less. Foodstuffs which supply *calcium* are milk, cheese, egg-yolk, green vegetables, grams, lentils, ground-nuts, and soya-beans. In places where the drinking-water is 'hard', some calcium is also obtained in this way (see also p. 164).

The daily *phosphorus* requirement is about 1 g., and the chief sources of this element are milk, cheese, and egg-yolk (these three foodstuffs also supply calcium), meat (especially liver and kidney), fish, nuts, legumes, and food-grains (see also p. 165).

About 0·01–0·02 g. of *iron* is required daily, and this element is essential for the formation of *haemoglobin* in the red blood-cells (see Bk. III). Foodstuffs which supply iron are sea-fish, egg-yolk, green vegetables, brown rice and whole-grain cereals, nuts, peas, and beans. Not all the iron present in the food can be absorbed, especially when there is an excess of phosphorus to combine with the iron and render it insoluble and therefore unavailable. So it is better to have more calcium than phosphorus in the diet; in fact, calcium carbonate is sometimes added to wheat-flour in order to get a proper ratio between phosphorus and calcium in the diet and thus ensure effective* absorption of iron (see p. 164).

The body excretes about 12 g. of sodium chloride (common salt) per day along with the urine, sweat, and faeces. About 2 g. of this is usually replaced from animal foodstuffs in the diet, so another 10 g. of common salt should be added to the food, especially when vegetable food forms a large proportion of the diet.

Although man's iodine requirement is very small (only about 0·005 g. per year), this element is essential for the proper development of body and brain. Iodine is present in sea-water, and small quantities are carried inland by winds bearing evaporated sea-spray. Plants absorb these iodine compounds from the soil, so that there is seldom any lack of iodine in the food except in regions very far from the sea, where it is sometimes necessary to add a little *sodium iodide* to the common salt used with food. Sea-salt and sea-water fish are good sources of iodine.

Lack of iodine causes one form of *goitre*, a disease of the *thyroid gland*, which lies in the front of the neck and contains one-quarter of all the iodine in the body (see Bk IV). In the commonest type of goitre, the thyroid gland becomes much enlarged, and any such swelling should be examined by a doctor, since although iodized table-salt usually *prevents* goitre, it will not always *cure* the disease. Since too much iodine in the diet may be dangerous to the health, any artificial addition of iodine should be under medical control. In some districts where goitre was formerly common, a suitable proportion of sodium iodide is added to all table-salt before distribution to shopkeepers for sale to the public.

Many experiments have been done (mostly with rats, but some with men), which have actually proved that carbohydrates, fats, proteins, water, and certain mineral salts are necessary to an animal if it is to grow or remain healthy. In 1910, while carrying out some of these experiments, in England, Professor Gowland Hopkins fed rats on a theoretically correct diet of *pure* carbohydrate, *pure* fat, *pure* protein, salts and water, which at that time were believed to be the five essential kinds of food. The rats became thinner and thinner and finally died, although they had 'plenty of food'. From this experiment, Hopkins concluded that there must be other '*accessory* food substances*' which must be present in an animal's food, though only in very small quantities. When he fed other rats on the same diet *with the addition of a small quantity of fresh milk or fresh fruit juice*, he found that the rats kept quite healthy, hence there must be something in fresh milk and fresh fruit which is essential for life, although only exceedingly small amounts are required to maintain health (see Fig. 1). It is now known that there are at least a dozen of these 'accessory food substances' which we call *vitamins*.

In the days of long voyages by sailing-ship, sailors often suffered from a painful and dangerous disease called *scurvy* when their voyages from port to port lasted for more than a few weeks. For example, Vasco da Gama, during his famous voyage round the Cape of Good Hope in 1498, lost over 100 seamen, all of whom died from scurvy. Captain Cook, in 1772, made his long voyage to Australia without any of his crew suffering from scurvy, and we now know that the fruit and vegetables which he included in their rations* supplied a vitamin which prevents scurvy. About the same time, Lind found that oranges and lemons cured scurvy (besides preventing it) and, in time, British ship-owners were compelled* by law to supply lemon-juice to their sailors during long voyages.

Another *deficiency*-disease* caused by lack of a vitamin is *beri-beri*. This disease attacked about one-third of the sailors in the Japanese Navy up to 1884, when the standard naval ration of meat and *white* rice was changed by substituting* *whole-grain* barley for part of the white rice. The Japanese Army ration of meat and white rice, however, was left unchanged. During the Russo-Japanese War, 200,000 Japanese *soldiers* suffered from beri-beri, *but no sailors*. So there seemed to be something in *whole-grain* barley which prevented the disease. At about the same time, in Java, the change-over from hand-mills to machine-mills producing whiter rice had been followed by more beri-beri. In 1897, Dr. Eijkmann, a prison-doctor, noticed that beri-beri attacked not only the prisoners but also the domestic

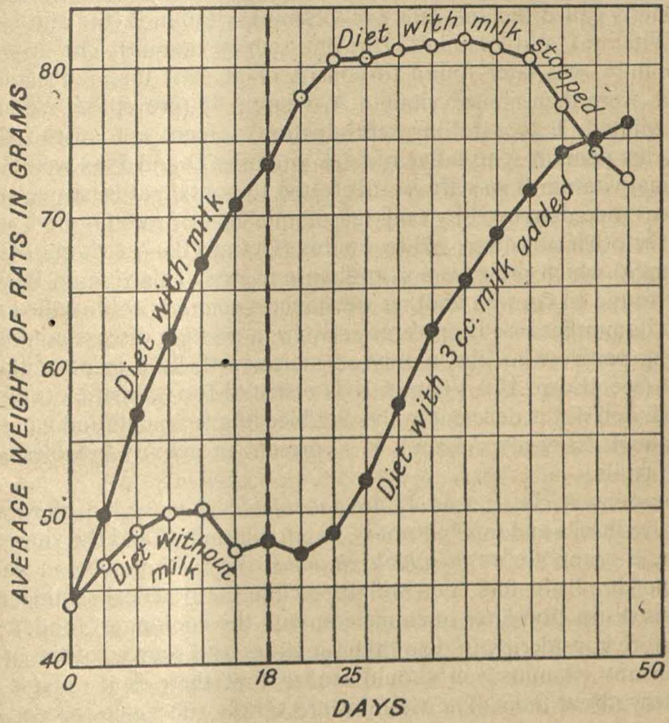

FIG. 1.—Results of one of Hopkins's historic experiments

hens which fed on waste food from the prison-kitchen. So he carried out experiments on the hens, feeding some of them on *whole-grain* rice, some on *half-milled* rice, and others on *white, polished* rice. *Beri-beri developed only among the birds fed on white rice* and was cured by giving them half-milled or whole-grain rice. Dr. Eijkmann then repeated his experiments on large numbers of human prisoners and found that 39 per cent. of those eating only white rice developed beri-beri, while only 1 in 10,000 of the prisoners eating half-milled rice got the disease. This experiment showed clearly that *there is something in the outer layers of the rice-grain that prevents beri-beri.* This substance was later called vitamin B.

The first *accessory food substances* to be identified were vitamin A (formerly called the anti-infective vitamin), vitamin B (the anti-beri-beri vitamin), and vitamin C (the anti-scurvy vitamin). The original vitamin A was later found to consist of at least three substances which were then named vitamin A, vitamin D (preventing *rickets*), and vitamin E (controlling reproduction). Hence a foodstuff that contains vitamin A usually contains vitamins D and E as well. The original vitamin B was afterwards found to contain at least two substances, one destroyed by boiling (vitamin B_1—preventing beri-beri) and the other not destroyed by boiling (vitamin B_2—or vitamin G in America) which prevents a skin-disease in rats. This vitamin B_2 was later found to contain another substance—*nicotinic acid*—called the P-P vitamin because it prevents *pellagra*, a wasting disease common among people who live mainly on maize, with little or no milk or meat (see also p. 17). Vitamin K is essential for normal clotting of blood, and if it is deficient in the diet bleeding from cuts and wounds is difficult to check. Vitamin K is present in green vegetables and fresh fruits.

Vitamins A, D, E, and K are *fat-soluble vitamins*, i.e. they will dissolve in oils and fats but not in water. Vitamin C and the vitamins of the B group are *water-soluble vitamins*; they will dissolve in water but not in oils or fats. You will appreciate the practical significance of this distinction later in connexion with the cooking of food.

Before considering in detail the functions and sources of the most important vitamins you should realize that there is no magic or mystery about them. The vitamins are simply substances needed by the body (in very small amounts) and which the body cannot itself supply. *If the diet is planned with reasonable care and intelligence, our daily food supplies enough of all the necessary vitamins*, and there should be no need to buy 'vitamin pills' from the drug*-store (although these concentrated vitamin preparations are very useful to doctors who fully understand their action and who have been trained to recognize the symptons* of vitamin deficiency). Remember that many of our ancestors* lived very long and quite healthy lives with no vitamins other than those derived* from their daily food. If you eat fresh, natural food—plenty of green vegetables, fresh fruit, milk, and eggs—you will get all the vitamins you need. Modern science has merely studied their action, isolated* them in a state of purity, analysed them chemically, and measured and standardized their effects, and some of them have even been *synthesized* in laboratories, i.e. built up from simpler constituents instead of being extracted from natural foodstuffs.

Vitamin A—its sources and effects

Vitamin A encourages healthy growth and physical fitness and, unlike vitamins B, C, and D, a shortage of vitamin A in the diet does not cause any special deficiency disease. Young animals, however, soon stop growing and then die if vitamin A is not present in their food. This vitamin keeps healthy the moist surfaces lining the food-canal, the lungs and air-passages, the ducts* of the various glands,* and the covering-tissue that lines the eye-lids and covers the front of the eye-ball. As vitamin A helps these tissues to build up resistance to infection,* it was formerly called the *anti-infective vitamin.* Some of the commonest disorders* among people in tropical countries are caused by a shortage of vitamin A, when these moist covering-tissues become dry and rough. This often causes a serious eye-disease, followed by infection of the air-passages. The skin may also become dry and rough. Another defect caused by shortage of vitamin A is '*night-blindness*', when the person affected can see distinctly only in bright light. All these ill-effects of vitamin A deficiency are commoner in tropical countries than elsewhere.

The actual substance vitamin A is found only in yellow animal fats (e.g. liver-fat and butter), in egg-yolk, milk, and cheese. It is particularly plentiful in fish-liver oils (e.g. of halibut, cod, and shark), hence fish-liver oils are used for preventing and curing diseases caused by lack of vitamin A (and they also supply vitamin D).

Although vitamin A itself is not present in plants, many plants produce a substance—*carotene*, formed from leaf-green—which our bodies can convert into vitamin A. Carotene is the yellowish-red colouring-matter in *carrots*; hence the name. Since both leaf-green and carotene are formed in sunlight, the deeper green a leaf is, the more carotene it usually contains. Hence the importance of *green, leafy vegetables* in the diet, as a source of carotene, which the body can convert into vitamin A. *Root*-vegetables (except when red or yellow in colour like carrots and red-skinned sweet potatoes) contain little or no carotene. Tomatoes, papayas, mangoes, and bananas contain more carotene than most other fruits. *Red*[1] *palm-oil* contains so much carotene that it can be used instead of cod-liver oil. It is therefore very valuable, both as a food-fat and for deep frying.*

Vitamin A and carotene are insoluble in water and they are not destroyed by heat unless oxygen is present. Boiling in water, therefore, does not result in much loss of either vitamin A or carotene. Shallow frying or roasting* in presence of air, however, will destroy some of the vitamin A in animal fats. Tinned meat and milk keep their vitamin A, as they are prepared and preserved in closed vessels, in the absence of air.

The vitamin A values of some common tropical foods are given on p. 161.

Vitamin B_1

Vitamin B_1 (or *thiamine*) is the *anti-beri-beri vitamin*, and if it is absent from the diet the digestive system is first disturbed, then the nerves, muscles, and heart become affected. Unless sufficient vitamin B_1 is supplied in time, the sufferer from beri-beri dies. The full disease is produced only by a serious shortage of vitamin B_1. If the diet contains some vitamin B_1, but not enough, then the nervous system, the digestive system, and the blood circulation are affected, but without producing clear signs of any special disease.

Beri-beri is commonest in countries where rice is the main foodstuff, because most of the vitamin B_1 is in the outer layers of the rice-grain and is removed when the grain is highly milled to produce *white* rice. Hence people that live mainly on white, polished rice without eating other foodstuffs rich in vitamin B_1 often suffer from beri-beri. For the same reason, a diet that consists mainly of *white* wheat-flour or cassava-flour (tapioca) may also cause beri-beri. The amount of vitamin B_1 required seems to depend partly on the amount of carbohydrate and fat eaten; the more carbohydrate, the greater the need of vitamin B_1, while fat has what is called a 'vitamin B_1 sparing' action. If the diet consists mainly of foodstuffs containing vitamin B_1, the correct balance is maintained, but if the diet consists mainly of white, polished rice, lacking in vitamin B_1, then the more rice that is eaten the sooner the deficiency is felt. Hence beri-beri attacks the 'over-fed' (who eat more white rice) before the 'under-fed' (who eat less white rice) if their other foodstuffs are the same.

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[1] i.e. palm-oil from which the red colour has not been removed.

A *little* vitamin B_1 is present in nearly all natural foodstuffs, but relatively rich sources are egg-yolk, liver and kidney, dried peas and beans, pulses, ground-nuts (pea-nuts), and *whole-grains* (e.g. rice, wheat, maize, millet, and barley). The richest source of vitamin B_1, however, is *yeast*, which is often used to correct vitamin B_1 deficiency and to prevent and cure beri-beri. *Food-yeast* is now prepared in large quantities in some tropical countries, the yeast (a microscopic one-celled plant) being grown on molasses, a by-product from the cane-sugar industry. Besides being an excellent source of vitamins of the B group, nearly half its dry weight consists of protein of good biological value. Yeast protein greatly improves the value of the protein present in cereals when eaten with them. In fact, experiments with animals have shown that when food-yeast is added to a cereal diet the value of the mixture is almost as great as that of a mixture of cereals and milk. Half an ounce of food-yeast per day is a very valuable addition to any diet.

Since *rice* is the main foodstuff of nearly half the world's population, it is important that its food-value should not be spoilt by bad methods of milling, storing, handling, and cooking. A comparison of the chemical analysis of 'brown' (husked)* rice with that of white (polished) rice shows that very serious losses take place during milling. About 30 per cent. of the protein is removed, 80 per cent. of the fat, 85 per cent. of the calcium compounds and 65 per cent. of the iron compounds. Beri-beri does not develop when whole, 'brown' rice or lightly-milled rice is eaten, since most of the vitamin B_1 is in the outer layers of the grain. Hand-pounded* brown rice retains* a large proportion of the outer layers and is therefore richer in thiamine than machine-milled white rice. A pound of *brown* rice per day supplies enough vitamin B_1 to protect a man from beri-beri, although this represents a bare minimum* of the vitamin. Most uneducated people, however, prefer white rice, from which all the outer layers and nearly all the vitamin B_1 have been removed by over-milling. They think white rice is 'cleaner', while shop-keepers find white rice more profitable to sell because it keeps longer than under-milled rice. Education is needed to change peoples' food-habits.

In some countries *parboiled* rice* is eaten in place of white rice, and in such areas beri-beri is very rare. Rice in the husk is first soaked in water and then steamed and dried before milling. During the soaking and steaming, some of the soluble vitamin B_1 diffuses into the middle of the grain so that it is not removed by milling. Parboiling also toughens the grain so that less damage is done when it is milled. Most grains of polished rice show a small hollow at one end (see Fig. 2) marking the spot previously occupied by the seed-plant (or embryo). Grains of parboiled rice, on the other hand, do not show this hollow because very little of the embryo has been rubbed off. Although the embryo forms only about 1·5 per cent. of the whole grain, it contains about 60 per cent. of the total thiamine. This is lost when rice is highly milled but retained when rice is milled after parboiling. The modern process of 'Rice-Conversion' is only a refinement of parboiling, but instead of being steamed at atmospheric pressure, and then dried in the sun, the grain is first subjected* to a greatly *reduced* pressure in 'vacuum' vessels before being soaked under greatly *increased* pressure. The 'converted rice' is then dried in 'vacuum' vessels before being milled as usual. The finished product retains about 90 per cent. of the thiamine present in the original grain. Parboiled and 'converted' rice, therefore, contain much more thiamine than ordinary white rice, and consumers* of these kinds of rice rarely suffer from beri-beri.

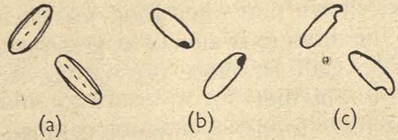

FIG. 2.—Stages in milling rice

(*a*) whole rice, (*b*) husked rice, (*c*) polished rice

Since over-milling of 'raw' rice removes most of the thiamine, fat, calcium, and iron, the 'rice-meal' removed during milling is a very valuable foodstuff; in fact, an extract of this material can be used for curing beri-beri. (In some countries this by-product from rice-mills is fed to pigs, so it is not surprising to find that pork is the only kind of meat containing much vitamin B_1.)

Where highly-milled white rice is the main foodstuff, the following special precautions are necessary to prevent beri-beri: (i) *The rice must be properly stored*, before and after milling, to prevent loss of its thiamine, i.e. the rice must first be thoroughly dried and then kept out of contact with the air. (ii) *The rice must not be washed before cooking*. Since thiamine is soluble in water, washing the rice before cooking removes most of this vitamin. When *polished* rice is used, washing is necessary to remove the powder used to polish the rice; hence the use of polishing-powders by rice-millers is undesirable from the consumer's point of view. If the rice has been properly stored and if it is freshly milled (without using a polishing-powder) then there is no need to wash it. (iii) *No excess of water must be used in cooking the rice*. If too much water is used, much of the thiamine and mineral salts will be extracted by the excess water. If the rice absorbs *all* the cooking-water, then there are no losses. (If the rice does not absorb all the cooking water, this must not be thrown away—it is particularly valuable for diluting tinned milk or for mixing with dried milk.) (iv) *More thiamine must be supplied by foodstuffs other than rice*, e.g. food-yeast, pulses, soya-beans, ground-nuts peas, or beans.

Vitamin B_1 is not destroyed by heat during cooking except in the presence of alkalis. Some people add a little baking-soda to the water in which green vegetables are cooked, in order to preserve their green colour. This is a very bad practice since it destroys any vitamin B (and also vitamin C). The vitamin B_1 values of some common tropical foodstuffs are given on p. 162.

Nicotinic acid—the pellagra-preventing vitamin

Pellagra is a disease that is commonest among people living mainly on maize and maize-products. The skin becomes rough and scaly and very painful, particularly when the affected places are exposed to sunlight. The digestive and nervous systems are also affected and, if proper treatment is not given, the patient* gradually wastes away. The disease is common in the southern part of the U.S.A., but it also exists in a number of tropical countries among people living mainly on grain products with little animal foodstuff. People that eat enough meat, eggs, fish, milk, cheese, and green leafy vegetables do not suffer from pellagra, because these protective foods contain *nicotinic acid* (or *niacin*), another vitamin of the B group, which is sometimes called the pellagra-preventing vitamin (or the P-P vitamin). Pellagra, however, probably always results from shortage of more than one vitamin besides nicotinic acid.

Yeast is very rich in nicotinic acid and is used to cure pellagra.

Riboflavin—vitamin B_2

Another vitamin of the B group is *riboflavin* (or vitamin B_2). A lack of riboflavin in the diet does not cause any definite 'deficiency disease', but it is essential for healthy growth and, along with thiamine and nicotinic acid, for proper utilization of carbohydrate by the body. It also helps to maintain the skin in healthy condition, particularly around the eyes and mouth. Riboflavin is most abundant* in meat (especially liver and kidney), milk, eggs, soya-beans, green leafy vegetables, and yeast.

Vitamin C—ascorbic acid

Vitamin C is the *anti-scurvy vitamin.* It has been identified as *ascorbic acid* since this substance, synthesized in the chemical laboratory, has exactly the same properties as the vitamin C that is present in fruits and vegetables. If vitamin C is absent from the diet for many weeks through lack of fresh fruit or vegetables, *scurvy* develops. Scurvy is a very serious disease which finally* affects almost every part of the body but particularly the blood-system, where the walls of the capillaries become so weakened that blood readily escapes into the tissues. The lightest blow causes a bad bruise.* Painful swellings form round the joints and in the limbs. The gums swell up round the teeth, which become loose. Scurvy always causes death unless vitamin C is supplied in time. Almost miraculous* cures are brought about in a few days by comparatively small quantities of orange-juice or lemon-juice, and, after 1795, scurvy was prevented in the British Navy by giving every sailor 1 ounce (= about 30 c.c.) of lemon-juice every day. A man's minimum daily requirement of vitamin C to prevent scurvy is 0·01 g. of ascorbic acid, but two or three times as much should be taken to ensure good general health, since a shortage of vitamin C causes other troubles besides scurvy. Shortage of vitamin C is very common in the diets of tropical races. In some cases, the deficiency is enough to cause scurvy, but in most cases, although the diet contains sufficient vitamin C to prevent the full disease, there is not enough of it to prevent other troubles, e.g. shortage of vitamin C in the diet lowers a man's resistance to bacterial infection, so that wounds form a lot of *pus* and heal very slowly. In the same way, a diet containing just enough vitamin C to prevent scurvy will not provide for proper bone and tooth formation, so that the teeth become loose and readily decay. The gums also become soft and bleed easily; in fact, this is one of the first signs of vitamin C deficiency.

Vitamin C is present in *fresh* fruits and green leafy vegetables, e.g. orange, lemon, pumelo, lime, guava, papaya, mango, pineapple, tomato, spinach, lettuce, French beans, cabbage, sweet potato. Papaya is particularly rich in vitamin C (and also in carotene, which can supply vitamin A).

Although many green leafy vegetables contain more vitamin C than fruits, *fresh fruit* is the most important source of vitamin C in practice because it is usually eaten raw and uncooked. Ascorbic acid is readily oxidized and is quickly destroyed by cooking, drying, or exposure to sunlight. Since vegetables are usually cooked before being eaten, much of their vitamin C is lost. *All* their vitamin C is destroyed if soda is added during cooking. The addition of acid, e.g. vinegar, lime-juice, or tamarind, however, preserves their vitamin C. Green vegetables should always be *cooked quickly*, using the smallest convenient quantity of boiling water, for about 10–15 minutes, if they are to retain as much of their vitamin C (and their carotene) as possible. (*Slow* cooking, even at a low temperature, destroys most of the vitamin C in vegetables.) Green leafy vegetables also lose much of their vitamin C (and of their carotene) if they are not eaten in *fresh* condition. Vegetables grown in the home garden and cooked in a young fresh condition, therefore, are better sources of vitamin C (and of carotene) than wilted* vegetables which have been picked a long time before they are used. Fruits and vegetables preserved in tins by modern methods retain their vitamin C since all the air is removed from their tissues before the tin is sealed. When fresh fruits and vegetables are unobtainable, the canned material is a good source of vitamin C.

Another valuable source of vitamin C when fresh fruits and vegetables are unobtainable is *germinating grains and pulses.** Although dried seeds contain little or no vitamin C, they produce comparatively large quantities of ascorbic acid when they germinate. If grains and pulses, e.g. millet, maize, barley, peas and beans (including soyabeans), after soaking in water, are allowed to germinate, these germinated seeds, eaten raw or after boiling for a short time, form a valuable foodstuff supplying vitamin C.

Animal flesh-foods, milk, and cheese contain little vitamin C. Remember that, for practical purposes, the best source of vitamin C is *fresh fruit, eaten raw* (after proper washing, of course, in the case of fruits not protected by a thick unbroken skin). The vitamin C values of some common tropical foodstuffs are given on p. 163.

Vitamin D—calciferol

Vitamin D is the *anti-rickets vitamin.* If there is a serious shortage of vitamin D in the body, then rickets develops. Rickets is mostly a disease of childhood in which the bones and teeth do not harden properly, although adults may suffer from similar bone diseases if they get too little vitamin D. Vitamin D acts by controlling the absorption of calcium and phosphorus compounds from the digested food as it passes through the small intestine. In the absence of vitamin D, although the food may contain plenty of calcium and phosphorus compounds, these elements are not absorbed.

Vitamin D is present in animal fats (along with vitamin A). The richest natural sources are the livers of fishes (e.g. shark, cod, halibut) and these *fish-liver oils* are used for preventing and curing rickets. Ordinary foodstuffs supplying vitamin D are fat fish, fat meat, egg-yolk, milk, and butter (if the cows have been exposed to sunlight). Most people living in tropical countries eat little animal fat and thus get little actual vitamin D *in their food.* Fortunately, however, green plants produce small quantities of a related substance called *ergosterol*, which is changed into vitamin D when it is exposed to sunlight. This change can also take place in the human skin if ergosterol is present in the fat underlying the skin. For this reason, rickets is an uncommon disease in the tropics, in spite of the small amount of animal fat usually eaten, but the disease sometimes attacks babies brought up inside dark houses and away from sunlight, especially when they are fed on sweetened condensed milk. The disease is not often seen in older children in the tropics because either the baby dies from chest, stomach, or intestinal complaints (to which rickety babies are specially liable) or else, after learning to crawl, the baby gets out into the sunlight often enough to cure the rickets. Remember, however, that exposure to sunlight alone will not prevent rickets. Ergosterol must first be present in the body, supplied by eating green leafy vegetables.

Although ergosterol is present in green plants in only small quantities, it is much more plentiful in *yeast*, and it is now extracted commercially from this source. After exposure to 'artificial sunlight' from mercury discharge lamps, this ergosterol is converted into *calciferol*, and this 'synthetic vitamin D' is added to foodstuffs that lack this vitamin, e.g. dried milk, and *margarine* (used instead of butter, and made from vegetable oils that lose their original vitamin D in the process of 'hardening' to produce solid fats). (*N.B.* Now that vitamin D can be bought so readily in concentrated form, e.g. in pills, there is a danger that ignorant people may take *far too much* and get deposits of calcium phosphate in the wrong parts of their bodies.)

PROTECTIVE FOODS

We have seen that although a man's first requirement is enough energy-yielding and body-building food, the diet must also include foods supplying vitamins and mineral salts, i.e. *protective foods.* After reading so much about the importance of vitamins, do not think that a man can live on vitamins alone; the diet must be adequate in *quantity* as well as in *quality*, and no amount of vitamins and mineral salts will keep a man healthy if his diet does not include sufficient energy-yielding and body-building food.

When the term 'protective foods' was first used, it was applied only to milk and green vegetables, but its meaning was later extended to include other foodstuffs rich in vitamins and mineral salts and also to a few other foodstuffs (obtained from animal sources) of special value for supplying the essential amino-acids. The list of protective foods published by one international authority includes green leafy vegetables, fresh fruits, whole-grain cereals and pulses, fish-liver oils, milk and milk-products, meat, fish, and eggs. These protective foodstuffs are often missing from tropical diets, one reason being that they are usually more expensive and less satisfying than carbohydrate foods. Another reason is that when the diet lacks protective foods there is not the same feeling of *hunger* as when energy-yielding foods are lacking. A shortage of protective food in the diet may not cause clear signs of illness, but people living on such badly-balanced diets exist only on the borderline of good health and never reach that physical and mental* well-being which is necessary to the enjoyment of full health with an active mind and a vigorous body.

When the diet lacks sufficient energy-yielding food, one feels hungry and tries to eat more food to satisfy the hungry feeling. Lack of protective food, on the other hand, does not cause obvious hunger but results in general tiredness and a lessened capacity* for mental and physical activity. These effects of shortage of protective food are not so easily recognized as the hunger that results from lack of energy-yielding foods, hence the need for intelligent *planning* of balanced diets. Fig. 3 shows, diagrammatically, the essential constituents of a balanced diet and the common foodstuffs that will supply these essentials. The table on p. 160 shows, in quantitative form, how everyday food needs can be met.

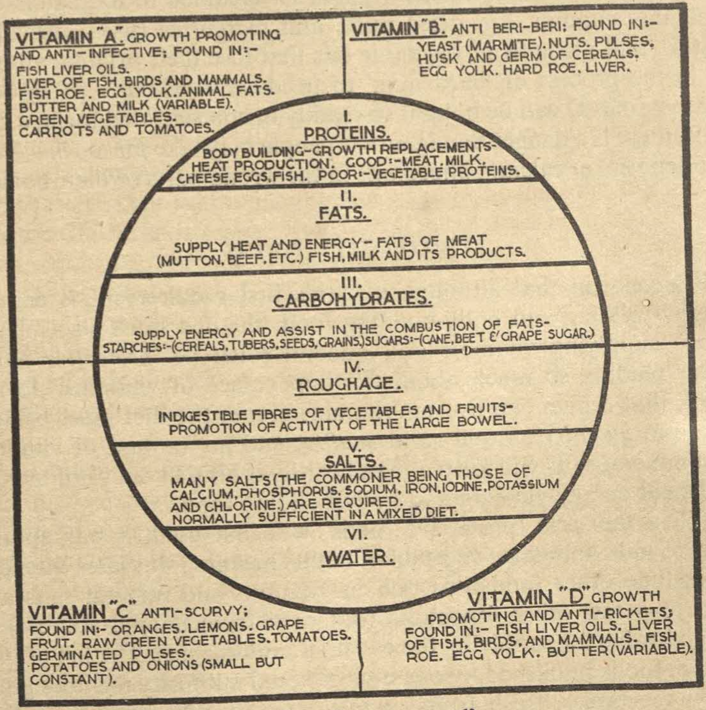
VITAMIN "A". GROWTH PROMOTING AND ANTI-INFECTIVE; FOUND IN:-
FISH LIVER OILS.
LIVER OF FISH, BIRDS AND MAMMALS.
FISH ROE. EGG YOLK. ANIMAL FATS.
BUTTER AND MILK (VARIABLE).
GREEN VEGETABLES.
CARROTS AND TOMATOES.
VITAMIN "B". ANTI BERI-BERI; FOUND IN:-
YEAST (MARMITE). NUTS. PULSES.
HUSK AND GERM OF CEREALS.
EGG YOLK. HARD ROE. LIVER.
I.
PROTEINS.
BODY BUILDING-GROWTH REPLACEMENTS-HEAT PRODUCTION. GOOD:-MEAT, MILK, CHEESE, EGGS, FISH. POOR:-VEGETABLE PROTEINS.
II.
FATS.
SUPPLY HEAT AND ENERGY-FATS OF MEAT (MUTTON, BEEF, ETC.) FISH, MILK AND ITS PRODUCTS.
III.
CARBOHYDRATES.
SUPPLY ENERGY AND ASSIST IN THE COMBUSTION OF FATS-STARCHES:-(CEREALS, TUBERS, SEEDS, GRAINS.) SUGARS:-(CANE, BEET & GRAPE SUGAR.)
IV.
ROUGHAGE.
INDIGESTIBLE FIBRES OF VEGETABLES AND FRUITS-PROMOTION OF ACTIVITY OF THE LARGE BOWEL.
V.
SALTS.
MANY SALTS (THE COMMONER BEING THOSE OF CALCIUM, PHOSPHORUS, SODIUM, IRON, IODINE, POTASSIUM AND CHLORINE.) ARE REQUIRED.
NORMALLY SUFFICIENT IN A MIXED DIET.
VI.
WATER.
VITAMIN "C" ANTI-SCURVY;
FOUND IN:- ORANGES. LEMONS. GRAPE FRUIT. RAW GREEN VEGETABLES. TOMATOES.
GERMINATED PULSES.
POTATOES AND ONIONS (SMALL BUT CONSTANT).
VITAMIN "D" GROWTH PROMOTING AND ANTI-RICKETS;
FOUND IN:- FISH LIVER OILS. LIVER OF FISH, BIRDS, AND MAMMALS. FISH ROE. EGG YOLK. BUTTER (VARIABLE).

FIG. 3.—'A square meal'

With the knowledge gained so far, you should now be able to judge for yourself the extravagant* claims made in advertisements of patent* medicines and foodstuffs which are said to do wonderful things for your health and strength. Uneducated people often waste a lot of money because, not having the necessary knowledge and outlook to check such claims, they believe any statement made in print.

SOME IMPORTANT FOODSTUFFS

Milk

The only single foodstuff that contains all the essentials of a good diet is milk. It contains a soluble carbohydrate (milk-sugar, or lactose), a substance found in no other natural food. The proteins of milk (e.g. casein) have the highest food-value of all proteins because they supply the amino-acids most needed for growth in the young and for repair in the adult. Milk-proteins, eaten together with cereals, improve the nutritive value of the 'poor' cereal-proteins. Milk-fat is present in the form of an emulsion (see Bk. IV) of different fats of low melting-point, providing the most easily digested kind of fat known to science. Milk is also particularly rich in mineral salts, especially in the calcium salts and phosphates necessary for building bone. Milk contains nearly all the essential vitamins, but the maximum amount of these is only found in the milk of dairy* animals fed on fresh, green herbage and exposed to sunlight. Vitamin C, however, is present in very small quantity, and as this vitamin may be destroyed by heating it is necessary to get it from another source, e.g. fresh fruit.

Milk forms a complete food for the young of mammals during their early life, and every different mammal produces a different kind of milk (containing different proportions of the above constituents—see Fig. 4) which forms a perfectly balanced food for its own young. After the earliest stages, however, solid food is necessary in addition to liquid milk.

Unfortunately, little or no milk is included in most tropical diets, and there are only a few tropical countries where milk-production from cows, buffaloes, sheep, goats, or camels is a profitable business. Unfortunately, also, milk may be either the most valuable or the most dangerous of foods, since it is so easily contaminated with disease organisms between the time it leaves the dairy animal and the time it is used for food (even when the animal that supplies the milk is perfectly healthy—which is not always the case). Badly neglected milk may contain more bacteria than sewage,* and may carry tuberculosis, typhoid fever, and diphtheria. In fact, a town's milk supply often needs more careful watching than its water supply. Hence the importance of making sure that the daily household supply comes from *healthy animals*, *cleanly milked* by healthy people, and that it is supplied in *clean, covered containers*.

The 'purity' of milk depends very largely on the precautions taken during milking, for it is while the animal is being milked that contamination most easily takes place. The following precautions are necessary: (*a*) the hind-quarters, udder,* and teats* must first be cleansed, (*b*) the milker must have clean, dry hands before beginning to milk and must keep them clean and dry while milking, (*c*) the vessels in which the milk is collected must be clean, and (*d*) milking must be done in a good light.

Milk, as it comes from the udder, is at the most favourable temperature for the growth and multiplication of bacteria. In modern dairies, therefore, the milk is usually cooled down as soon as possible (to not more than 50° F.) so as to check the multiplication of germs (without, however, killing those already present). To kill harmful germs (particularly those of tuberculosis) milk may be *pasteurized* by heating it to not less than 142° F. and keeping it at this temperature for not less than 30 minutes. The pasteurized milk is then *cooled very quickly* to not more than 50° F. If milk is *boiled* (at 212° F.), harmful germs are killed, but the food-value of the boiled milk is lower than that of pasteurized milk.

In many tropical countries it is so difficult to get a daily supply of fresh, clean milk from healthy dairy cattle that imported, *preserved milk* has to take the place of fresh milk as a protective food. Milk is preserved commercially in two main ways: (*a*) as *evaporated* or *condensed milk*, containing all the constituents of fresh milk, and (*b*) as *dried milk*. *Evaporated milk* is simply milk from which about half the water has been removed by evaporation. Diluted with the proper amount of water, evaporated milk forms a good substitute for fresh milk and can even be used as an artificial food for babies. It does not keep long, however, once the can is opened. *Condensed milk* is milk from which most of the water has been removed and to

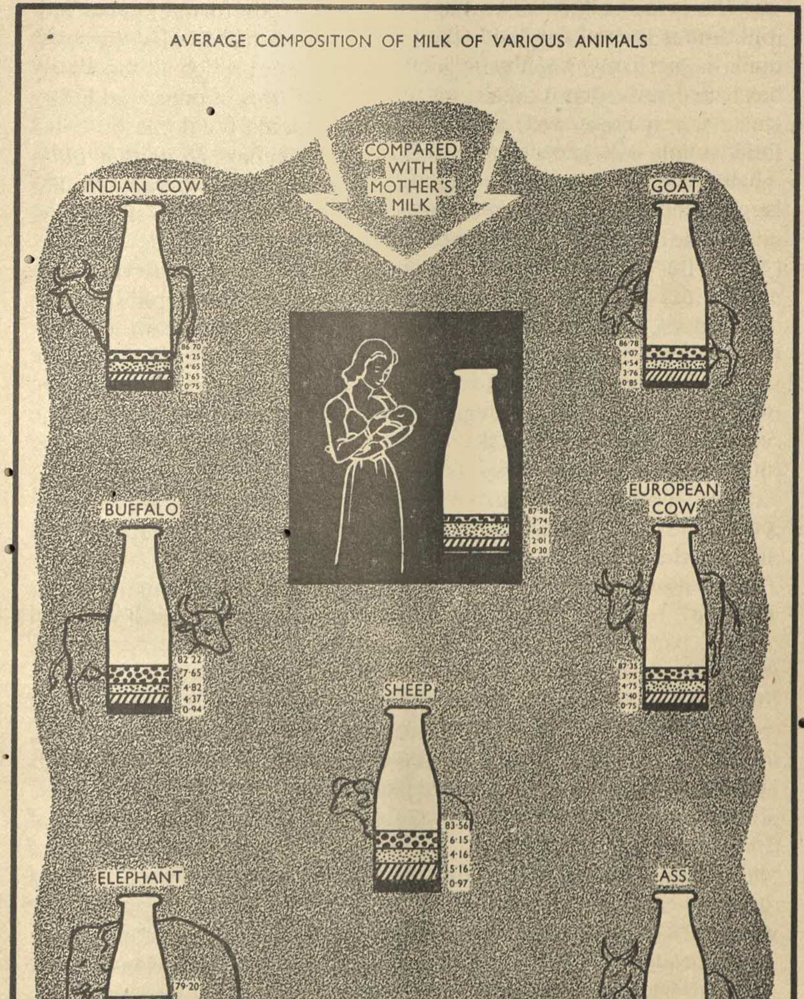

FIG. 4.—Comparative milk values

which cane-sugar has been added; it is *not* the best form of preserved milk for feeding babies, being liable* to cause boils* and looseness of the bowels.* *Dried whole milk* is whole milk from which all the water has been removed and this is one of the best forms of preserved milk. It is clean, it keeps well, and it is easily prepared for domestic uses. Dried whole milk is the best artificial food for babies. *Dried skim milk* (or dried *separated* milk) is made from 'skimmed' or 'separated' milk, i.e. milk from which the fat (or cream) has been removed by skimming or mechanical separation. Hence it lacks fat and fat-soluble vitamins (A and D). Dried skim milk is the cheapest form of preserved milk and as it is such a rich source of proteins, calcium and phosphorus compounds, and vitamin B, it provides a valuable addition to most tropical diets, e.g. it supplies almost everything that is missing from the usual rice-eater's diet. Dried skim milk is sometimes mixed with one volume of buffalo milk (of very high fat content) and one volume of water, thus doubling the existing milk supply in some areas. (*N.B.* Babies should never be fed entirely on dried *skim* milk, because vitamins A and D are removed along with the milk-fat when the milk is skimmed; the addition of egg-yolk,* however, will replace the missing vitamins and fat.)

Cheese, which contains milk-protein and milk-fat, has many of the valuable food properties of milk and makes a good substitute for meat.

Eggs

Eggs are a very valuable foodstuff, being particularly rich in protein (mainly in the egg-white) and fat (mainly in the yolk), besides containing mineral salts and vitamins (A, B, D, and E—but *not* C). Hence eggs, eaten with carbohydrate foodstuffs, can supply a complete, properly balanced meal. Eggs make an excellent substitute for meat.

Egg-white contains four first-class proteins which supply all the essential amino-acids. Egg-yolk contains valuable quantities of vitamin B (in addition to vitamins A and D); it is about 30 per cent. fat and it also contains two first-class proteins, in addition to numerous mineral salts (including large quantities of *iron* in a form which is easily absorbed). Eggs and milk make a very good food-combination, since the deficiency of vitamin D and iron in milk can be made up from eggs. Eggs, on the other hand, lack calcium salts, which are plentiful in milk.

By keeping a few hens, fed mainly on waste foodstuffs, many families could provide themselves with a very valuable addition to their diet.

Fish

In many tropical countries, fish is the only animal protein which can be had at reasonable cost. Unfortunately, little has yet been done to make full use of the enormous* wealth of protein food available in tropical seas, but several countries are now beginning to improve their methods of catching and marketing fish.

Fish is a very valuable foodstuff, supplying first-class protein to the diet. We have seen that fish-livers and 'fat' fishes are also very rich in vitamin A; sea-fish also supply iodine. Hence fish is a very suitable addition to diets consisting mainly of rice or other grains. The food-value of fish is greatest when it is *fresh.* Unfortunately, however, fish-flesh decomposes rapidly, particularly at high temperatures, and in many tropical areas dried fish is all that can be had. Cold storage is the best method of preserving fish, but it is an expensive method, used mainly in large towns. The commonest method of preserving fish is by drying, either in the sun or by hot smoke, but this usually destroys vitamins A and D. Another method is by using common salt, either by salting and drying, or by 'pickling'* the fish in strong salt solution or brine.

Legumes

The seeds of many leguminous (pod-bearing) plants are valuable foodstuffs, because they supply vegetable proteins that are of high food-value when eaten with animal proteins or when added to a diet consisting mainly of rice or other grains. When eaten together, peas and rice, grams and rice, peas and maize, are of greater food-value than when eaten separately. Maize, millet, and soya-bean is one of the best combinations of this kind.

The *soya-bean* is a very important leguminous foodstuff since it contains a high proportion of good protein and fat; it is also rich in calcium compounds. We have seen (p. 19) that germinated soya-beans are rich in vitamin C. When cooked whole, soya-beans are difficult to digest, hence they are usually 'processed' to produce more readily digestible products, e.g. soya-bean flour, soya-bean 'milk', and soya-bean 'curd'.* Soya-bean 'milk' is readily digestible and has a high food-value corresponding to about 80 per cent. of that of good cows' milk. The paste* left after separating the 'milk' can be used for other food preparations. With the addition of calcium sulphate, common salt, egg-yolk, and invert sugar (see Bk. IV), soya-bean milk forms a good substitute for animal milk and can even be used as a complete food for babies.

Other legumes of high food-value are ground-nuts (rich in protein, fat, and vitamin B_1), lentils, cow-peas, pigeon-peas, lima-beans, dolichos-beans, French beans, long beans, and grams.

Green leafy vegetables and fruits

Fresh fruits and green leafy vegetables are needed to supply 'protective' vitamins and mineral salts. Fresh green vegetables, eaten raw (e.g. in the form of salads*), are a good source of vitamin C (ascorbic acid). In many tropical countries, however, great caution is necessary before raw, uncooked vegetables are eaten owing to the danger of intestinal disease. Leafy vegetables bought in the market or from a hawker* have sometimes been grown under insanitary conditions (e.g. in soil manured* with raw human excreta*) and they are often allowed to lie on dirty surfaces and to be handled by dirty hands. Vegetables from such sources are safer after cooking; it is dangerous to eat them raw. The safest source of supply for your green salad vegetables is *your own garden*; failing this, get them from a known safe source, e.g. a Government or municipal* market garden, where they are grown under proper conditions, strictly supervised.* In any case, vegetables that are to be eaten raw should be well washed in clean water before they are eaten.

If you cannot be sure of the cleanliness of your local supply of green vegetables, it is safer to get your vitamin C from fresh fruits (the edible* part of which is less liable to contamination since it is usually protected by a skin). Fruits with damaged or broken skins should be regarded with strong suspicion. Fruits of good 'protective' value are the citrus fruits (e.g. oranges, lemons, limes, pumeloes, grape-fruit), tomatoes, papayas, pineapples, guavas, mangoes, and chillies.

When green leafy vegetables are being cooked, remember that vitamin C is easily destroyed by bad cooking. Also remember that the cooking-water contains valuable mineral salts and vitamins; it should therefore be used and not thrown away. The following rules should be observed: (i) Use green leafy vegetables *as fresh as possible*; if you grow your own (the best way) do not gather them until just before you are ready to cook them. (ii) *Wash* vegetables thoroughly (but do not *soak* them for a long time) before cooking. (iii) Use *only just enough cooking-water* to prevent burning. (iv) Add about one tea-spoonful of common salt to every pound of vegetables (but do not add any soda). (v) Keep the lid on the cooking-vessel (so that the vegetables are 'steamed' rather than 'stewed').* (vi) Boil green leafy vegetables for *10–15 minutes only*. (vii) Drain off any excess liquid and use it for making soup or gravy.* (viii) Eat the cooked vegetables as soon as possible. (There is a very good reason underlying every one of these eight rules; can you think of one in each case?)

Sugar

Refined white sugar supplies nothing but energy; it has no protective value and should be used only in moderation. It is better (and cheaper) to use *starch* as your main source of energy rather than eat too much sugar. In the food-canal, the conversion of insoluble starch into soluble simple sugars is relatively slow, hence after a meal of mainly starchy food absorption of sugar from the small intestine goes on slowly and steadily without overloading the liver (which, you will remember, regulates the amount of sugar entering the blood-stream). Sweet foods, however, contain soluble sugar that is digested and absorbed very quickly, so that a lot of sugar reaches the liver in a short space of time. Under normal conditions, a steady supply of sugar to the liver is better than a sudden rush. Under abnormal conditions, however, e.g. when the blood-sugar is too low owing to lack of food or over-exertion, eating sugar will soon put things right. In fact, the simplest remedy for feeling faint is sugar, e.g. sweetened coffee or sweetened fruit-juice, because this is the quickest way of increasing the amount of glucose in the blood-stream. Sugar and sweet foods, therefore, provide a useful 'pick-me-up', but starchy foods are more satisfying and more satisfactory as a general rule. Over-sweetened starchy foods, also, often cause fermentation* and 'wind' in the food-canal.

Unrefined sweetening agents like molasses and brown sugar are of greater food-value than refined white sugar because their protective 'impurities' have not been removed. Molasses and brown sugar, for example, contain some mineral salts (particularly iron compounds) and they may also supply vitamins of the B group.

COOKING

Most of our food is not eaten raw, but is first cooked. Cooking makes the food more appetizing,* thus indirectly helping digestion by stimulating* the flow of digestive juices, e.g. we notice an increased flow of saliva when appetizing food is seen or smelt.

When meat is properly cooked, the tough bundles of muscle-fibres are split up so that cooked meat is easier to chew* with the teeth and is more readily acted upon by the digestive juices in the food-canal.

When vegetables are cooked, the plant-cells are burst open so that the digestive juices in the food-canal can act on the cell-contents more readily. At the same time, the starch-grains inside the cells are also burst open so that the starch is more readily digested.

Properly cooked bread and pastry* is porous and spongy;* hence, when it is eaten, the digestive juices can act on the porous food much more readily than if it were in dense,* solid lumps. The particles of flour are separated from one another by the expansion of air, carbon dioxide, and steam. When flour and water are mixed together by kneading* with the hands, air is trapped in the sticky dough.* When the dough is heated, these bubbles of air expand and make the bread porous. Some of the water in the dough, too, forms bubbles of steam, thus producing the same effect as the bubbles of air. It is usual, however, to set free carbon dioxide in the dough before or during baking by using either *yeast* or *baking-powder* (a mixture of sodium bicarbonate with a weak acid). The bubbles of carbon dioxide that are formed cannot escape from the sticky dough and, during baking, they expand and force apart the particles of dough.

Another important result of cooking food is that the high temperature used kills disease organisms and parasites* that may be present in the raw food. Cooking makes meat and fish more attractive and should also make them more digestible, but it has, in addition, the very important effect of killing disease organisms, e.g. bacteria and parasitic worms. Cooked meat will keep longer than uncooked meat. Fish decays very rapidly in a hot climate and should always be cooked as soon as possible. Shell-fish decompose particularly quickly and very often carry disease organisms, so they should only be bought alive, to ensure freshness, and should then be cooked very thoroughly.

Food hygiene

It is most important that food should be stored, prepared, served, and eaten in a clean and hygienic way. The kitchen should be the cleanest place in the home; it should be well lighted, so that dirt and insects are easily seen and removed. The floor should be of smoothly-finished waterproof material so that it can be swept clean and washed easily. Table-tops and other working-surfaces should be kept clean by frequent scrubbing* with soap and water. A rat-proof and fly-proof store-room or store-cupboard ('meat-safe') should be available for storing food. The wash-place (or 'sink') should be well drained and easily cleaned. Those handling and preparing other people's food should be scrupulously* clean in their persons and in their habits; dirty hands (and dirty finger-nails) are *dangerous* if they come in contact with food. Cooking vessels need very careful cleaning with soap and water (not just dry sand or ashes) to ensure that no food is left sticking on them to decay and to feed bacteria. Chipped* or cracked vessels may be dangerous because of disease germs inside small openings where they cannot be washed away. Table-ware* should be washed in *hot* soapy water and then rinsed* in *clean* water before being placed on a draining-stand to dry. This is better than wiping with a cloth, because unless the cloth is perfectly clean it does more harm than good. A dirty 'dish-cloth' or kitchen-towel is a paradise* for bacteria and contaminates everything it wipes. Remember that although things may 'look clean' you cannot see disease germs without a microscope.

Notice that the important factor is always *cleanliness*—with clean hands, clean food, clean water, and clean surroundings we can avoid most of the diseases that enter the body by way of the mouth. In practice, the best aids to cleanliness are soap and hot water.

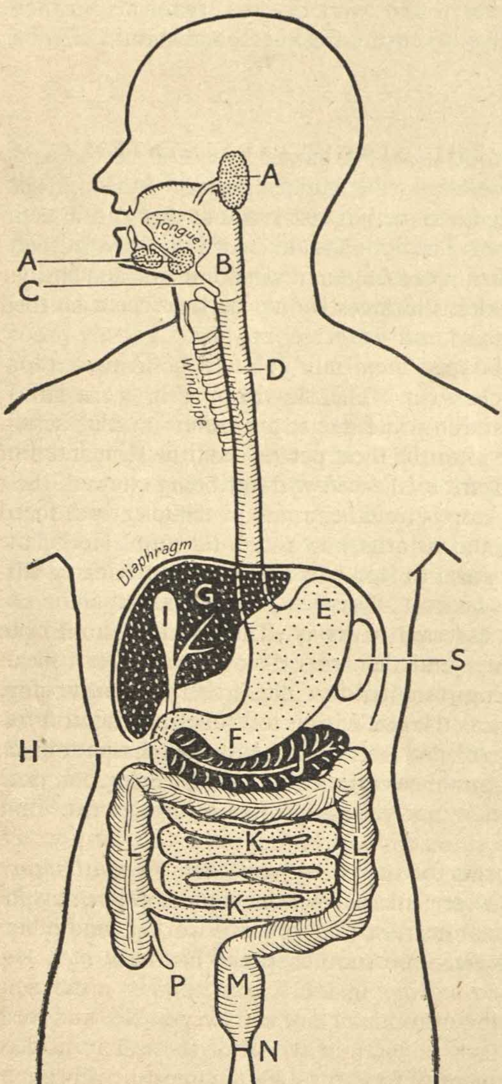

FIG. 5.—The Digestive System (diagrammatic)

A—Salivary glands. B—Throat (pharynx). C—Epiglottis. D—Gullet (oesophagus). E—Upper end of stomach. F—Pylorus. G—Part of liver. H—Bile and pancreatic ducts. I—Gall bladder. J—Pancreas. K—Small intestine. L—Large intestine. M—Rectum. N—Canal to anus. P—Appendix. S—Spleen (not concerned with digestion)

CHAPTER 2

HYGIENE OF THE ALIMENTARY SYSTEM

DISORDERS OF THE DIGESTIVE SYSTEM

Now that we know something of food and nutrition we can consider some of the ways in which the digestive organs may be disturbed during the digestion of food.

In the first place, it is very important to chew solid food thoroughly, *particularly starchy food.* The enzyme ptyalin, in the saliva, begins the digestion of starch while it is in the mouth and its action continues for some time after the food has reached the stomach. But if *lumps* of starchy food are swallowed without being chewed, their digestion by ptyalin will stop before the lumps are sufficiently reduced in size to pass through the pylorus into the duodenum. Hence the lumps of starchy food stay too long in the stomach, causing discomfort and sourness.

An ordinary meal is digested and passed on by the stomach in about four hours, hence a space of five or six hours between meals enables the stomach to complete its work and have a short rest before dealing with the next meal. Hence, eating too much, eating too frequently, and eating at irregular intervals may overwork the stomach and cause digestive disturbance. One simple remedy for this is to give the stomach a rest by not eating solid food for several hours and by washing out the stomach by drinking plenty of warm water.

The commonest disorder of the digestive system is *constipation,* when faeces remain too long in the rectum. Constipation may be caused by lack of muscular exercise (e.g. in office workers and others who sit down while working). Another cause is *faulty diet,* e.g. irregular meals, lack of *roughage* in the food, drinking insufficient water, inadequate chewing of food, lack of leafy vegetables and fresh fruits in the diet, and lack of vitamin B; all of these may lead to constipation. The movement of food through the intestine is brought about by peristalsis, i.e. by waves of muscle movements squeezing the semi-liquid food along (Fig. 6). This action is much more efficient when the intestine is fairly full, hence it is better to have a few good meals with several hours between them, rather than frequent small meals. This is one of the objections to the habit of eating between meals. Fibrous matter in the food (e.g. cellulose and fibres of fruits, green vegetables, and whole-grain cereals) absorbs liquid as it passes along the food-canal and so produces bulk,* which provides a natural remedy for constipation caused by sluggish* movements of the intestinal muscle-walls. A well-balanced diet should supply about 2 gm. of such indigestible fibre (or roughage) obtained in equal proportions from fruits, vegetables, and cereals. Drinking plenty of water (plain or flavoured) *between meals* also helps to prevent constipation.

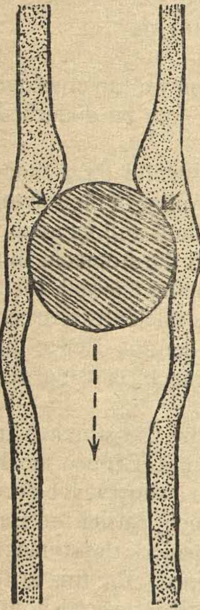

FIG. 6.—How food is squeezed along the food-canal

A regular daily evacuation* (or motion*) of faeces from the large intestine is one of the first essentials of good health. Irregularity in emptying the bowel is a common cause of constipation, for if the urge to defaecate (i.e. discharge faeces) is neglected the muscular walls of the rectum relax and the urge disappears. If the walls of the rectum are kept stretched in this way the muscles lose some of their power to contract and although a small quantity of faeces may be passed the rectum is not properly emptied at each motion. By using the latrine at the same time each day (preferably in the early morning) it is possible to establish a *regular habit* of emptying the bowel quickly, completely, and without strain. Muscular exercise helps to maintain regular and healthy working of the bowels by strengthening the muscular body-wall of the abdomen and thus keeping the digestive organs in their proper place in the belly-cavity.

To sum up, constipation may be avoided (*a*) by taking regular meals with plenty of fruit, green vegetables and whole-grain cereals, to supply 'roughage', (*b*) by taking regular exercise, (*c*) by drinking plenty of water between meals, (*d*) by making sure that the diet supplies sufficient vitamin B_1 (see also p. 14), and (*e*) by encouraging a regular habit of evacuating the contents of the large intestine *at the same time each day.*

The frequent use of *laxatives* (or 'loosening' medicines) is one of the commonest *causes* of habitual constipation, and they should only be used if prescribed* by a doctor. Under no circumstances should an active laxative (or *purgative*) be given to anyone suffering from any sharp pain in the abdomen. In such cases there is always a danger that a strong purgative may burst the bowel and thus cause infection of the peritoneum (peritonitis), often with fatal* results.

Even when all the digestive organs are healthy and in good working order, the digestive process may be upset by external factors, e.g. when a person is over-tired, frightened, or angry, the digestive juices do not flow freely, and indigestion may result if food is eaten by anyone in such a disturbed state. Conversely, a good appetite, pleasant company and happy surroundings, and the sight and smell of attractive food encourage the flow of saliva and other digestive juices necessary for good digestion.

PARASITES OF THE FOOD-CANAL

Intestinal worms

In tropical countries there are several kinds of worms which may enter the human food-canal and live as parasites in the intestine; in fact very few people are entirely free from such worms, which feed on the digested, semi-liquid food in their host's* bowel. Such intestinal worms interfere with the absorption of food, *particularly in babies and young children*, causing a great deal of sickness and even death in many tropical countries, where more than 90 per cent. of the population may be infected with these parasitic worms. In fact, this is one of the main causes of 'backwardness' among individuals and communities in some 'under-developed' countries.

Infection is carried by contaminated food and water, and by dirty hands and food-vessels, so we can guard against becoming infected with worms (*a*) by boiling any suspicious drinking-water, (*b*) by not walking barefoot on mud or in dirty water, (*c*) by not bathing in dirty water, (*d*) by thoroughly cooking meat and vegetables, (*e*) by carefully washing raw fruit before eating it, avoiding any fruit whose skin is broken, and most important of all, (*f*) by improved sanitation* (e.g. proper latrines) and cleanly habits.

Round-worms

The female round-worm (see Fig. 7) lays thousands of eggs, which may remain alive in damp soil for over a year. Fruit and vegetables often become dirty with soil containing round-worm eggs. If such fruit and vegetables are eaten raw without first being washed clean, then the eggs enter the food-canal and hatch out into round-worm *larvae** in the upper part of the small intestine. These larvae bore their way through the wall of the intestine and reach the portal vein, which carries blood to the liver. They are carried first to the liver and then to the lungs by the blood-stream. The round-worm larva then bores through into an air-sac and is coughed up the wind-pipe to the throat, down which it is swallowed for a second time to spend its adult stages in the small intestine. Adult round-worms may grow to a length of 20–40 cm., as big as earth-worms, absorbing digested food from their host. Round-worms are easily killed and can be removed by a doctor with the aid of drugs.

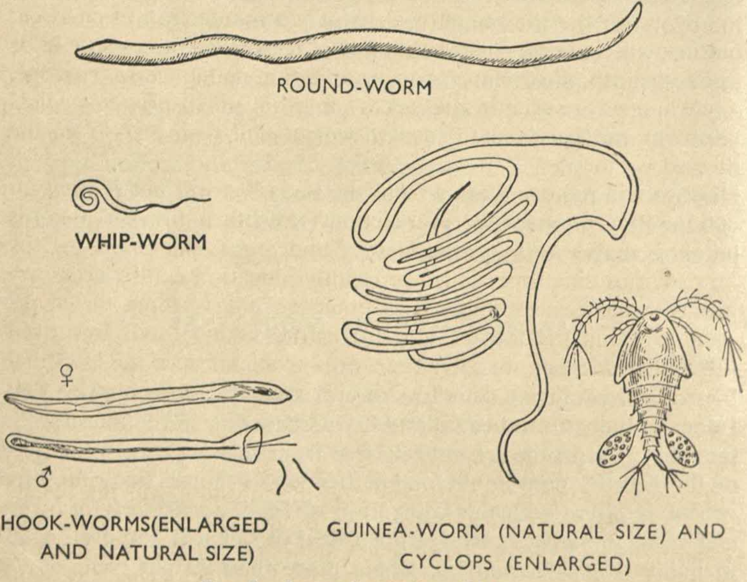
ROUND-WORM
WHIP-WORM
♀
♂
HOOK-WORMS(ENLARGED AND NATURAL SIZE)
GUINEA-WORM (NATURAL SIZE) AND CYCLOPS (ENLARGED)

FIG. 7.—Internal parasites of Man

♀ female ♂ male

Round-worm larvae cause serious irritation* to the stomach, small intestine, and lungs, resulting in indigestion, constipation, and faulty absorption of food. The intestinal walls are weakened and the abdomen swells (pot-belly), the patient fails to grow and gain weight. Children with worms very often have running noses. The stomach irritation sometimes causes a child to eat dirt and thus become further infected. All these factors cause stupidity and laziness in a child of good natural intelligence. Parents and teachers, therefore, should be always on the look-out for signs of worm-infection in children, and in suspected cases a small sample of the child's faeces should be sent to a hospital or clinic* for examination under the microscope. If worm eggs are seen in the faeces (or 'stool') then proper medical treatment can be given to remove worms and their eggs from the infected person.

Drugs will remove worms from the body but will not *prevent* infection. Prevention of worm-infection (and other 'filth-diseases') is mainly a matter of *improved housing* and *proper sanitation*, e.g. by the provision of proper latrines. Health education is also necessary to encourage healthy habits and practices, e.g. washing the hands (*a*) after using the latrine, and (*b*) before taking food. Improved nutrition alone will not solve the worm-problem, since the intestinal worms feed on their host's food and irritate his food-canal so that it does not absorb food properly.

Thread-worms and whip-worms

Thread-worms do not multiply inside the intestine, but the female worm crawls out of the anus and lays thousands of eggs in the surrounding skin. This produces severe itching,* which often leads to scratching, so that eggs get under the finger-nails and may be conveyed to the mouth. In this way more parasites are introduced into the food-canal. An itching nose also is a common sign of thread-worm infection.

Whip-worm eggs pass out with the faeces, and when such faeces are allowed to lie about on the ground and become dry, the tiny eggs are blown by the wind and may infect foodstuffs (see Fig. 7).

Proper medical treatment is necessary to remove thread-worms and whip-worms from the body.

Hook-worms

The most dangerous intestinal worm is the *hook-worm*, common in all warm countries (see Fig. 7). Hook-worms attach themselves to the wall of the intestine and suck blood, thus gradually weakening their host (see Fig. 8).

If there are a lot of hook-worms present in a man's intestine, and if no treatment is given, he becomes weaker and weaker and may die. The hook-worms lay eggs which pass out with the faeces, and if the eggs find their way into damp, warm earth they hatch out into tiny hook-worms.

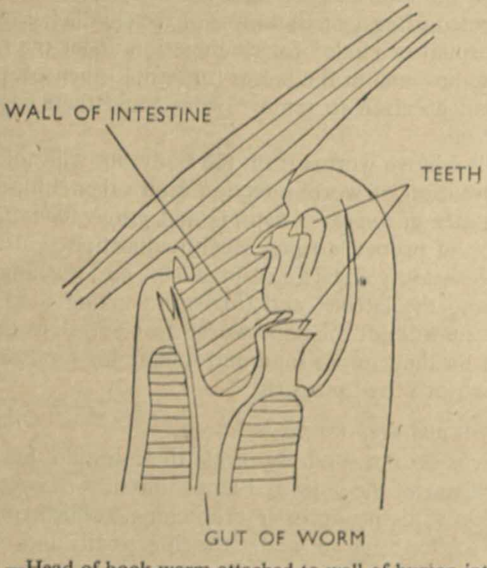

Fig. 8.—Head of hook-worm attached to wall of human intestine (diagrammatic and highly magnified)

These young hook-worms enter the intestine by a roundabout path. If a man walks barefoot on infected soil the tiny hook-worms enter the skin and make their way into the *lymph-vessels,* whence they are carried to the main blood-stream. As the blood flows through the capillaries of the lungs, the tiny hook-worms bore their way through into the air-sacs and are coughed up from the air-passages. Many of them are swallowed and pass through the stomach into the intestine, where they attach themselves and suck blood from their host and mate, thus reproducing themselves and completing the life-cycle. A single hook-worm can remove 0·5 c.c. of blood per day, and as infection by a *thousand* worms is not uncommon, a heavily infected man may lose *several pints* of blood per day.

People harbouring* large numbers of hook-worms seem always tired and lazy; actually they are sick and need treatment. Fortunately, it is not difficult for a doctor to remove all the hook-worms from a man's intestine by a few doses of medicine, and re-infection can be prevented (*a*) by not walking barefoot, (*b*) by the proper disposal of faeces (so as not to infect the soil or water), and (*c*) by carefully washing the hands and feet soon after they have been in contact with the soil.

Tape-worms

A tape-worm looks like a piece of jointed white ribbon or tape,* and may grow to a length of several feet (see Fig. 9). The 'head'* attaches itself to the wall of the intestine and the worm absorbs digested food through its large surface as it floats in its host's intestine. Joints from the other free end of the tape-worm, full of embryos,* break off from time to time and pass out with the faeces. If a pig swallows an embryo, it bores its way through the wall of this animal's intestine and enters its muscles, developing into a 'bladder-worm'. (This name refers to its shape and does *not* mean that it lives in the host's

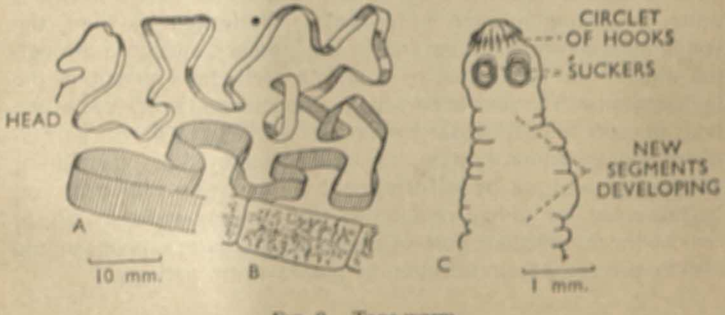

FIG. 9 Tape-worm

A—first few inches of a tape-worm several feet long (about natural size). B—ripe joint, containing eggs, from end of tape-worm (about natural size). C—head of tape-worm (× 10) bladder.) If a man eats raw or under-cooked meat infected in this way, the bladder worms attach themselves to the wall of his intestine and develop into tape-worms, thus completing the life-cycle. In civilized countries meat and fish are examined by Health Inspectors before being offered for sale, and if they contain worms they are condemned and destroyed. In any case, if the meat is thoroughly cooked, such parasites will be killed.

Guinea-worms

This parasite is common in some parts of Africa and India. The adult female guinea-worm (which may grow to a length of several feet) lies just beneath the skin, usually in the legs and feet, where it can be either seen or felt under the skin (see Fig. 7). The female worm then passes out a milky liquid containing enormous numbers of embryo worms, usually forming a white blister* on the skin. These embryos escape into water (usually while bathing), and if they enter the body-cavity of their intermediate* host—*Cyclops* (a small fresh-water flea)—they grow to a length of about 1 mm. in 4–6 weeks. If water containing infected water-fleas is swallowed by Man, the young guinea-worms are set free in the stomach and bore through the wall of the food-canal to complete their development in the human tissues. The female parasite only comes to the surface of the body in order to pass out the embryo worms. When a female guinea-worm appears under the skin, it should be removed in a hospital or dispensary* and not by self-treatment. Guinea-worm infection can be prevented by boiling or filtering the drinking-water to kill or remove the intermediate host—*Cyclops*. Public water supplies should also be protected from infection by guinea-worm patients.

INTESTINAL DISEASES

Dysentery, *typhoid*, and *cholera* are infectious intestinal diseases of the filth*-borne type, because the organisms which cause these diseases enter the mouth along with food and water which have been contaminated by human filth. In fact, they are '*anus-to-mouth infections*' because these organisms do not exist outside the body except in material fairly recently contaminated by faeces from an infected person. So remember that every case of these intestinal diseases is caused by that person *swallowing excreta*. These diseases were formerly called 'water-borne diseases', because in the days before careful attention was given to public water supplies, infected drinking-water was the cause of serious outbreaks of these diseases.

House-flies often act as carriers of dysentery and typhoid, feeding on infected faeces and carrying the disease germs to human food. The germs may be carried sticking to the hairy legs of the fly (see Fig. 10) and also in its food-canal, where they can live for several days, being passed out either in the fly's faeces or in its vomit,* since before a fly takes in its food it softens it by vomiting the contents of its crop.* An average house-fly carries over a million bacteria (though not all harmful ones). It is therefore most important to protect all food from flies and also, by the sanitary disposal of refuse, to stop flies from breeding (see p. 147).

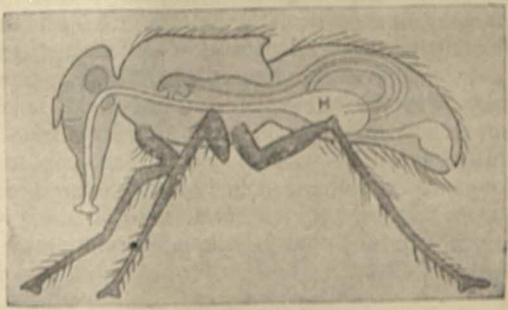

FIG. 10.—Section through house-fly (diagrammatic and highly magnified) showing sucking-tube and crop—H; also hairy legs

Dysentery

Dysentery is a disease of the large intestine caused by dysentery bacteria (bacterial dysentery) or by an organism larger than bacteria —the dysentery *amoeba* (causing amoebic dysentery). Motions become frequent and the faeces become watery and mixed with blood and mucus. There is often severe pain in the abdomen. Microscopic examination of the stool is necessary to identify the cause of the disease, and early medical treatment should be sought. In the meantime, no solid food should be taken but *plenty of liquid* (to make up for all the water lost in the stool), e.g. weak tea (hot or cold), rice-water, barley-water, Marmite in water, or beef-tea or chicken-tea.

The organisms causing dysentery are passed out along with the patient's faeces, hence the only effective way of stopping the spread of the disease is the proper disposal of infected faeces, so that water supplies and foodstuffs are not infected (and so that flies cannot get at faeces).

Dysentery usually comes from one's own home or from one's immediate community, so one usually knows of nearby cases and can take special precautions, being particularly careful to drink only boiled water and milk, to cook all vegetables, to wash carefully any fruit which is to be eaten raw and to protect food from flies and cockroaches. (*N.B.* It is particularly important that no one suffering from the slightest persistent* looseness of the bowels, or recovering from this disorder, should be allowed to handle other people's food or food-vessels.) People are sometimes infected with dysentery organisms without feeling unwell, and if such 'healthy carriers' are dirty in their habits, and especially if they handle food supplies, they may be very dangerous to others. Amoebic dysentery is particularly dangerous from this point of view because the patient may have the dysentery amoeba in his bowel for a long time without knowing it.

Typhoid fever

Typhoid fever and the less dangerous *para-typhoid fever* are both diseases of the small intestine. In typhoid fever, sores are formed in the intestine, and the great danger is that a sore may burst and make a hole in the wall of the intestine, causing death. Hence the patient

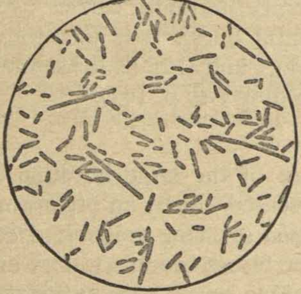

FIG. 11.—Typhoid bacteria (highly magnified)

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must not be given any solid food until he has recovered from the disease. New drugs have revolutionized* the treatment of typhoid and the sooner a fever-patient is examined by a doctor the better.

Typhoid bacteria (see Fig. 11) are present in the faeces and sometimes in the urine, saliva, or sweat of the patient, hence the greatest care must be taken in disposing of infected faeces and in washing the patient's clothing and bed-clothes, so that the typhoid bacteria cannot get into food or drink. To avoid catching typhoid one should drink only purified or boiled water and ensure that all foodstuffs (particularly milk) have been protected from dirt and insects. Living typhoid bacteria have been found on, or in, house-flies three weeks after the flies have been in contact with infected faeces (see Fig. 10).

Typhoid and para-typhoid bacteria can live in ice, which should not be put *into* drinks unless it is known to be made from pure water.

Another way in which typhoid can be spread is by the 'healthy carrier', the person who seems to be healthy although he carries typhoid germs in his bowel and may discharge them when his bowels are opened. If such 'healthy carriers' are not discovered and prevented from handling food as cooks, food-hawkers, ice-cream sellers, &c., and if they do not wash their hands thoroughly after using the latrine, they may convey infected material to other people's food. Many typhoid *epidemics* (or sudden outbreaks) have been caused in this way, and public health authorities are always on the look-out for such carriers. When an epidemic breaks out, if one particular person is found to have been in contact with the food of all the patients, his stool is examined by the health authorities, and if this is found to contain typhoid bacteria, this person is not allowed to work in any food-handling business.

Protection against typhoid fever is given by injecting* killed typhoid bacteria under the skin, in three doses, at intervals of about a week. This anti-typhoid inoculation is harmless and gives protection against the disease for about a year. The most important factor in preventing outbreaks of typhoid fever is, however, proper sanitation and clean personal habits.

Cholera

Asiatic cholera is a very infectious intestinal disease and is perhaps the most terrible of all tropical diseases, for over 50 per cent. of those that get the disease die from it unless treated promptly. About two days after infection, the patient has very frequent watery motions for a few hours; he then becomes unconscious and, in most cases, dies. In this way, the disease may kill hundreds of people in a few hours.

With such a terrible disease, *prevention* is the most important thing, and as in the case of the other intestinal diseases, the only way of becoming infected is to swallow the disease organisms. In countries where cholera is common, it is nearly always spread in drinking-water, hence the first step towards preventing cholera is a pure public water supply. If the disease appears, the patients must be taken to an 'isolation hospital' at once, so that proper treatment can be given; and care must be taken to destroy infected faeces and to disinfect everything used by the patient. At the same time healthy persons in the community must continue the usual boiling of all water and milk, the thorough cooking of all meat and vegetables, the protection of all foodstuffs and food utensils from insects, and the washing of hands in boiled water before handling any food. Cholera can be completely controlled by proper sanitation.

APPENDICITIS

Appendicitis is an inflammation[1] of the *appendix*, the small, blind-ended tube (about the size of a finger) which opens out of the *caecum*, i.e. the beginning of the large intestine (see Fig. 12). In plant-eating mammals, the appendix is very large and plays an important part in digesting cellulose, but in Man it appears to be useless and even a source of danger, particularly to people who eat a lot of meat.

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[1] *Inflammation* is a medical term which is often used in everyday life without any clear idea of its meaning. When any part of the body becomes hot, swollen, painful, and red, it is said to be *inflamed*. Such inflammation is usually a sign of bacterial infection, showing the natural protective action of the body in trying to get rid of the cause of the disturbance, to limit its action, and to repair any damage. For example, when the skin is broken and pus-forming bacteria enter a wound, there is an increased supply of blood to the damaged area of the skin, bringing more white blood-cells to deal with the invading bacteria. This increased supply of blood causes a local rise of temperature, redness and swelling in that part. The increased pressure on the sensitive nerve-endings in this part of the skin causes pain and tenderness. Inflammation itself is not a disease, but a sign of the body's reaction to infection. This natural resistance often overcomes the invading organisms and their harmful products without outside help in the form of medical treatment.

Tenderness or pain in the lower part of the belly region, often on the right side, is a common sign of appendicitis, and in such cases *it is most important not to take purging medicine*, e.g. castor-oil or 'salts', because this produces violent movements of the intestine and may cause the inflamed appendix to burst, with very serious results. If belly-pains are frequent or lasting, a doctor should be consulted as soon as possible, before taking food or medicine, because self-treatment is responsible for many deaths through appendicitis. *Early* treatment (which sometimes involves removal of the diseased appendix by a surgeon*) will prevent many deaths through appendicitis. Appendicitis is *not* caused by swallowing small seeds when eating fruit. It is usually caused by the appendix becoming infected with *pus-forming bacteria* (see also p. 70).

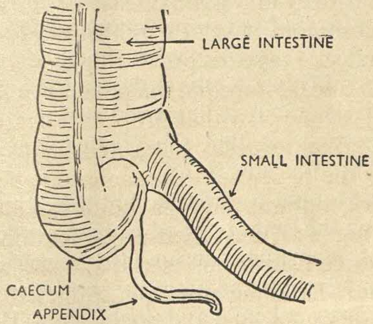

FIG. 12.—Human appendix

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CHAPTER 3

HYGIENE OF THE RESPIRATORY SYSTEM

In breathing, the blood is brought very close to the air in the lungs. It gives up carbon dioxide (and some water), which it brings from all parts of the body, and takes up oxygen, which it carries around the body to every cell. By lifting the ribs and flattening out the diaphragm the volume of the chest-cavity is increased and the pressure of the air in the lungs is lessened, so that the greater atmospheric pressure outside forces air into the lungs.

No one has to be taught to breathe, but it is sometimes necessary to learn how to keep the lungs in good working order, because under civilized conditions people who do no hard muscular work often use only a part of their lungs. If the lungs are only partly used day after day, they may become weakened and unable to work to their original full capacity. It is most important, therefore, that for a few minutes at least, every day, the lungs should be fully exercised. This can be done by daily deep breathing-exercises, workings the ribs and diaphragm to their full extent, or better still, by active exercise, e.g. running, which makes one 'out of breath' and produces rapid, deep breathing. In this way regular and suitable exercise will enlarge the lungs and make them capable of harder work. It is clear that tight clothes and belts will discourage proper breathing movements. A bent posture* of the body when standing up or sitting down also restricts* the movement of the ribs and diaphragm and so hinders proper breathing. Measurement of 'chest expansion' shows whether the lungs are in good working order or not. This should be about three inches.

The nose is specially adapted for cleaning, moistening, and warming the air as it is breathed in, but the mouth has these safeguards less well developed. Hence by day and by night all ordinary breathing should be through the nose.

The action of the nose in filtering out dust from the air during breathing is very important. Air always contains varying amounts of dust (living and non-living). The 'non-living dust' consists of tiny particles of earth and stone, bits of animal hair and dead skin, bits of fibres worn away from clothing, bits of plant parts, and particles of soot* from the smoke of fires. Unless this dust is filtered out from the air as it is breathed in, there will be formed a coating of dirt lining the branching air-tubes and tiny air-sacs in the lungs, and the exchange of gases between the blood and the air will be hindered. The 'living dust' often contains some disease organisms, and in correct breathing these are usually trapped as they enter the nose.

Diseases which can be carried by air and enter the body by way of the respiratory system are *sore throat*, the *common cold*, *diphtheria*, *influenza*, *whooping-cough*, *measles*, *smallpox*, *chicken-pox*, and *consumption* (i.e. tuberculosis of the lungs).

THE IMPORTANCE OF FRESH, CLEAN AIR

We have learnt the importance of good, clean food. A plentiful supply of fresh, clean air is equally necessary. There is no difficulty about this among people that live open-air lives, but under the artificial conditions of civilization it is often necessary to take special care to ensure a plentiful supply of fresh air. We have seen that nearly all impurities in air are harmful, and that the most dangerous impurities are the organisms which spread disease from one person to another. Such diseases can only be spread if people breathe *in* air which has already been breathed *out* by a diseased person.

Ventilation

The first step towards preventing the spread of 'airborne diseases' (i.e. diseases whose germs float in the air) is to ensure that air which has recently passed through one person's lungs is not re-breathed by someone else. This is ensured by proper *ventilation*, i.e. by changing the air frequently and thus reducing the risk of infection.

In tropical countries, there need be little difficulty about getting plenty of fresh air. Buildings with open sides, or with plenty of doors and windows on two or three sides, allow fresh air to flow through from outside, and this natural ventilation is usually quite adequate in well-planned buildings. The ventilation of sleeping-rooms at night is just as important as that of rooms used in the daytime. Some people think that 'night-air' is unhealthy, so they close all their windows at night and sometimes even cover up their heads as well. This is quite wrong, and it is just as important to breathe fresh air at night as in the daytime, hence windows of sleeping-rooms should be kept open.

(The use of bars, or 'expanded metal', will prevent thieves from entering.)

In tropical countries, artificial ventilation is usually only necessary in large halls, e.g. cinemas, that are crowded with people. Under such conditions, electric fans have to be used. These should be arranged so as to blow in fresh air or to draw out breathed air. When artificial ventilation is used, there should be a supply of *at least* 1,000 cubic feet of fresh air per hour for each person in the room, but two or three times this amount is better.

The cooling effect of ventilation

We have seen that one important reason for ventilation is the need to reduce the danger of spreading infection by airborne diseases.

Another very important reason for ventilation is connected with the physical condition of the air—its *humidity*,* its *temperature*, and its *movement*. It was formerly thought that a badly-ventilated room feels uncomfortable because the breathed air contains less oxygen and more carbon dioxide than fresh air. Experiments have shown that this explanation is wrong; even the worst-ventilated rooms never contain sufficient carbon dioxide to do any harm. If you entered a room containing only 13 per cent. oxygen (as against 21 per cent. oxygen out-of-doors) you would not notice the difference; in fact so long as the air inside a room contains more than 10 per cent. oxygen a man feels much the same as in the fresh air outside. So lack of oxygen is not responsible for the discomfort one feels through lack of ventilation. A crowded and badly-ventilated room feels uncomfortable because (*a*) *the temperature of the air is too high*, (*b*) *there is too much water vapour in the air*, and (*c*) *the air is not in motion*. In the tropics, the main aim of ventilation is to *keep the air moving, since the main effect of bad ventilation on bodily comfort is due to lack of cooling power by the air.*

Man is a 'warm-blooded' or 'constant-temperature' animal, and the body-temperature is regulated mainly by the loss of excess heat from the skin. (Roughly 75 per cent. of the heat produced in the body is given out by way of the skin.) Some of this excess heat is got rid of by conduction, convection, and radiation, the capillary* blood-vessels in the skin being flooded with blood when the body-temperature rises under warm outside conditions (see also p. 54). The most important method of getting rid of excess heat, however, is by the evaporation of sweat, the necessary *latent heat** being taken from the skin. But in order to produce a cooling effect, *the sweat must evaporate*, and in a badly-ventilated room filled with still, damp air, the sweat cannot evaporate fast enough to cool the body sufficiently.

The main problem of ventilation, therefore, is to increase the *cooling power* of the air; hence, *while good ventilation should provide a plentiful supply of fresh air, it is also necessary that this air should be constantly moving.*

Fig. 13 shows an important experiment illustrating these principles. A man was placed in a room which was divided into two parts A and B by a hanging curtain of non-porous material. In one experiment, cool, dry air (i.e. 'fresh' air) was passed through B (i.e. over the man's *body*), and warm, damp air containing nearly 1 per cent. carbon dioxide (i.e. 'foul' air) was passed through A, yet *the man felt no discomfort although he was breathing 'foul' air*. In a second experiment, 'fresh' air was passed through A and 'foul' air through B, and *the man felt uncomfortable although he was breathing 'fresh' air*. These two experiments show clearly that the main effect of ventilation is on the *skin* and *not* on the lungs.

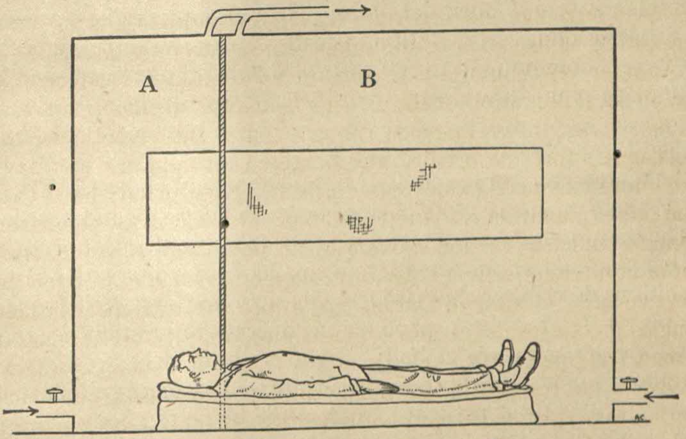

FIG. 13.—'The man in two rooms'

People doing hard physical work under very hot and very humid conditions may suffer from *heat-sickness* or *heat-exhaustion*. the commonest form being *heat-stroke*, when there is high fever owing to the failure of the circulatory system. The victim, however, usually recovers rapidly after removal to a cool place, especially if the skin is sprinkled* with water and then cooled by fanning.

Heat cramp is another complaint that affects people working under hot conditions, e.g. stokers in ships' engine-rooms, miners, iron- and steel-workers. Heat cramp is brought on by drinking large quantities of water to quench the thirst caused by excessive sweating. Sweat contains salt, so that during heavy sweating not only is much water lost from the body but also a lot of salt. If large quantities of salt-free water are then drunk the concentration of salt in the blood is reduced and this may cause muscular cramp. Heat cramp may be prevented by drinking dilute salt solution instead of plain water (using about one part of common salt to 500 parts of water, i.e. one teaspoonful of salt to one pint of water).

Regulation of body-temperature

If the temperature of the body is to be kept steady between 97° and 99° F. there must be a close balance between heat-gain and heat-loss.

The body *gains heat* from two sources: (*a*) from the heat produced during *internal respiration* and (to a smaller extent and under certain conditions described below) (*b*) from its surroundings. We have seen, on pp. 3–7, that heat production due to respiration is about 1 Calorie per kilogram of body-weight per hour, when resting, and that the amount of heat produced is increased by increased muscular activity. If there was no heat-loss from the body, the body-temperature would rise about 1° C. (= 1·8° F.) per hour under resting conditions and it would rise still more rapidly during exercise. But our mechanism* for temperature regulation is so efficient that the body-temperature is kept very nearly the same at all times. It is only during very strenuous* exercise or when the surrounding air is much hotter than the body and nearly saturated* with water vapour that heat is lost too slowly to preserve the normal body-temperature in a healthy person. Most of the heat gained by the body is produced inside the body-cells during respiration and is carried to all parts of the body by the blood-stream. Since respiration goes on continuously, the body is always receiving heat from this internal source. The body can also take in heat from external sources under certain conditions, e.g. when the surrounding air-temperature is higher than the skin-temperature or when the body-surface is exposed to sunshine, but such external sources supply much less heat to the body than it gets from internal respiration.

The body *loses heat* mainly from the *skin*, though some body-heat is also lost during breathing (as will be explained later in this chapter). Three distinct physical processes are responsible for heat-loss from the skin. In order of their relative importance under tropical conditions, these are (i) by *evaporation of water* from the skin, (ii) by *radiation* from the body-surface to cooler neighbouring objects, and (iii) by *conduction* and *convection* to the surrounding atmosphere when the air-temperature is lower than that of the skin. These methods of heat-loss require further explanation.

(i) *Heat-loss by evaporation of water*

The main factor in heat-loss at high temperatures, or when the muscles are in very active use, is evaporation of water from the skin. Even under cool conditions, the skin is always giving off a little water vapour, but under hot conditions, or when hard muscular work is being done, large quantities of water are lost as *sweat*, sometimes as much as a litre in an hour. This sweat escapes from the *sweat-pores* in the skin. It is formed in knots of coiled tubules—*sweat-glands*—deep down in the skin, and it passes along the *sweat-ducts* to the *sweat-pores* (see Fig. 40).

Sweat is mainly water and the sweat-glands remove this water from the blood as it flows through the skin. The evaporation of 1 gm. of water from the skin at 97° F. requires about 0·58 Calories (= 580 'small calories') of heat. Most of this *latent heat* is taken from the skin itself, thus cooling it. Hence the more sweat *evaporated from the skin* the more heat lost by the body. Since evaporation is more rapid in moving air than in still air, a current of air 'feels cooler' than still air of the same temperature and humidity. It is important to realize, however, that sweating can have no cooling effect unless the sweat evaporates. When drops of liquid sweat remain on the skin without evaporating there is great discomfort owing to the lack of any cooling effect. This is why a hot, damp atmosphere, almost saturated with water vapour, is so much less comfortable than a dry atmosphere *at exactly the same temperature*.

'The real test of our cooling powers comes either when the air is much hotter than our bodies, or when it is so saturated with water that the sweat cannot evaporate, and merely runs uselessly down our skins. It is amazing what great heat we can stand provided the air is dry. The first man who investigated just how high a temperature he could stand was Mr. Blagden, who was Secretary of the Royal Society towards the end of the eighteenth century. He went into a room heated to 260° F., which is 48° above the boiling-point of water. He stayed there for over three-quarters of an hour, during which time a beefsteak was not merely roasted, but baked till it was quite hard. He took in a dog, which was kept in a basket so as not to burn its feet, and the dog managed to keep cool too. To show how evaporation cools things, he took in two pots of water. On one he dropped some wax, which melted, and prevented water vapour from escaping. The temperature of this pot rose much more than that of the one with a free surface.

'This experiment was done in dry air. Wet air is a very different story. In air at body temperature which is completely saturated with water one sweats vigorously, but it is no use. No water evaporates, and the body temperature rises by 2° or 3° F. per hour. I have once been in saturated air at 120° F. It was terrible. Every breath heated my throat and lungs. We had clinical thermometers, and every minute we took them very quickly out of our mouths and read them in cold water. For, of course, in the air they would have gone up at a great rate. Our temperature rose nearly a degree a minute. I stayed in for a very short time.' [1]

Heat is also lost by evaporation of water from the moist surfaces of the lungs and air-passages during breathing, but the amount of heat lost in this way is not affected by changes in the external temperature until *panting** begins, exposing a larger surface area of the tongue and mouth-cavity and changing the air more frequently by rapid, shallow breathing. Panting provides an important method of heat-loss among mammals with thick fur and few sweat-glands, e.g. dogs. A dog pants very rapidly under hot external conditions or after strenuous exercise and thus increases heat-loss by evaporation of water from the tongue and from the surface of the mouth cavity.

(ii) *Heat-loss by radiation*

Radiation is the transfer of heat from one object to another *without any physical contact between them.* For example, the sun radiates heat to the earth through the empty space that exists outside the earth's atmosphere, the sun's heat-waves travelling in the same way as its light-waves and with the same speed (186,000 miles per second). Whenever two neighbouring objects are at different temperatures, heat is *radiated* from the surface of the hotter object and is *absorbed* through the surface of the cooler object, and the greater the difference in temperature the greater the amount of heat exchanged. The human body radiates heat to every cooler object in its neighbourhood, e.g. to the furniture, walls, floor, and ceiling of a room, and this is the main factor in heat-loss from the body *at low temperatures*. When the air temperature is between 70° and 80° F. (= 21° to 27° C.) about two-thirds of the total heat-loss takes place by radiation, but once the air-temperature exceeds the skin-temperature then there can be no cooling by radiation, only by evaporation of water from the skin.

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[1] From J. B. S. Haldane, *Keeping Cool.*

(iii) *Heat-loss by conduction and convection*

Conduction is the transfer of heat to any cooler substance *in contact* with the body, e.g. the air which covers the skin and the air which enters the lungs and air-passages during breathing receive heat from the body *by conduction* if the external atmosphere is below body-temperature. Conduction is a much less important means of heat-loss than either evaporation or radiation. The skin of most mammals is covered by a layer of hair or fur and that of birds by feathers. These body-coverings entrap air to form a heat-insulating* coat over the skin. Man has little body-hair and in cold climates he has to prevent dangerous heat-loss by wearing insulating clothes which maintain a layer of air (a bad conductor of heat) next to the skin. A layer of fat under the skin serves a similar purpose since fat is a bad conductor of heat.

Convection is the transfer of heat along with *moving* gases or liquids, and this process accompanies conduction in removing heat from the skin. Cool air in contact with the skin is warmed by conduction, expands, becomes 'lighter', and therefore rises upwards. Cool air flows in to take the place of this warmed air, producing a *convection current* of air which conveys heat away from the body. Cooling by convection is increased by exposure to moving air, e.g. the breeze* produced by a fan, since air in contact with the skin (and thus warmed by conduction) is swept away more rapidly, carrying more heat with it. Heat-loss by conduction and convection is greater when the external air-temperature is low. As the air-temperature rises, less and less heat is lost by these processes, until when the air-temperature exceeds the skin-temperature there is no further heat-loss by conduction and convection.

We have seen that heat is lost mainly from the skin surface. But this heat was produced in the deeper tissues during respiration and has been brought to the surface of the body by the blood-stream. So the amount of heat brought to the surface of the body depends on the rate at which blood flows through the skin. When the muscular walls of the branch arteries supplying blood to the skin-capillaries contract, less blood will reach the skin and less heat will be brought to the surface. Conversely, if the diameter of these blood-vessels increases, more blood will flow through the skin, bringing more heat to the surface and making the skin warmer. These changes in the diameter of the blood-vessels in the skin are controlled by a part of the brain that is sensitive to small changes in the temperature of its blood-supply and thus acts as a 'thermostat' in regulating body-temperature.

When the external atmosphere is cooler than the body-temperature some heat is also lost from the lungs by warming the inspired* air to body-temperature. The cooler and drier the air the greater the heat-loss in this way, through the lungs.

DISEASES WHICH ENTER THE BODY THROUGH THE AIR-PASSAGES

The respiratory tract* (like the food-canal) is really part of the external environment,* there being direct communication between the nose, throat, and lungs and the outside air. As a result of this, the germs of a number of diseases can enter the body by way of the air-passages, although there is very little danger of infection if clean, fresh air is breathed. Fresh air, out-of-doors, contains comparatively few bacteria of any kind. Disease-producing bacteria, in particular, soon die in fresh air and sunlight. But in badly-ventilated and overcrowded rooms, the air often contains many disease-producing bacteria—floating on particles of dust or in tiny drops of water—and a healthy person may breathe in sufficient of the bacteria to catch the disease. Infectious diseases like the common cold, influenza, measles, whooping-cough, diphtheria, smallpox, and consumption are usually spread in this way.

During normal, steady breathing, the breathed-out air contains very few bacteria, since the damp, sticky surfaces of the air-passages (particularly the nose-cavity) hold back nearly all the solid particles. But when air is forced out suddenly, as in sneezing, coughing, or even speaking, some of the liquid lining the air-passages is blown out as a fine spray of tiny drops of mucus and saliva. In this way an infected person, while coughing or sneezing, produces a spray of infected *droplets*,* containing millions of bacteria. By the proper use of a handkerchief, however, most of these droplets can be caught as they leave the mouth and nose, otherwise the spray may travel some distance, and healthy persons within five or six feet may breathe in enough infected droplets to catch the disease. '*Droplet infection*' is the commonest way in which people catch what were formerly called 'airborne' diseases.

There are several ways of preventing the spread of diseases by *droplet infection*: (i) People who are coughing or sneezing badly should isolate themselves, e.g. stay at home, or better still, stay in bed; (ii) the proper use of a handkerchief will trap the infected droplets; (iii) rooms should be properly ventilated; (iv) overcrowding should be avoided, so as to keep healthy people beyond 'spraying distance' of infected people (e.g. sickness in the British Army was greatly reduced when the distance between soldiers' beds in barracks* was increased to over three feet); (v) by having clean, dustless surroundings. In clean, dust-free air, most of the droplets fall to the ground and do no further harm; but if the room is dusty, when the dust is stirred up the infected dust-particles float about in the air and spread infection.

Diphtheria

This infectious disease, which is commonest in temperate climates, is caused by diphtheria bacteria that attack the lining of the nose, throat, and wind-pipe (see Fig. 14). Diphtheria is commonest and most dangerous in young children between three and five years of age. The disease is usually spread by droplet infection from the sick to the healthy. Children may also become infected by drinking from an infected cup or sucking an infected pencil. Diphtheria bacteria can also live on books and furniture, e.g. on door-handles. Unfortunately, some people are *diphtheria carriers*, being infected with the germ although they appear quite healthy. Such '*healthy carriers*' can infect others by droplet infection when they cough or sneeze.

A few hours or days after infection the patient develops a sore throat and a rise in temperature. As the bacteria multiply, they form a greyish-white film across the throat, which, in bad cases, may block the windpipe. By examining the saliva and mucus on the back of the throat a doctor can find out whether a 'sore throat' is due to diphtheria bacteria or not.

If diphtheria bacteria are present, *diphtheria anti-toxin* is injected into the patient. This is made by cultivating diphtheria germs, and then filtering the culture* to separate the bacteria from the poisonous substance (or *toxin*) they produce. This *toxin* is injected, in small doses, into a healthy horse, which gradually produces in its blood an *anti-toxin* to neutralize the toxin. Blood is then taken from the horse and filtered to remove blood-cells and any possible bacteria, and the filtrate, containing the diphtheria anti-toxin, is packed in sealed tubes and sent to doctors and hospitals for use when required.

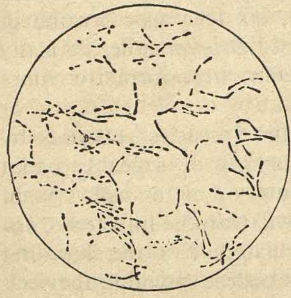

FIG. 14.—Diphtheria bacteria (highly magnified)

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Owing to the rapidity with which diphtheria develops, it is most important that the anti-toxin should be injected into the patient's blood-stream as soon as possible. One day's delay may make all the difference between the life and death of the patient. Every child with a sore throat, therefore, should be examined by a doctor *at once*. As the anti-toxin injection is harmless and will also prevent a healthy person from catching diphtheria during the following few weeks, it is usual to inject it into anyone who has been in contact with a diphtheria case. This injection gives protection (*passive immunity*) against diphtheria infection for a few weeks only. After the throat is quite better, a diphtheria patient has to be kept very quiet for at least a month because there is a danger that the heart muscle may become permanently weakened.

A child of 9–12 months can be made *actively immune** to diphtheria by another simple and harmless treatment consisting of two or three injections of a different preparation of diphtheria toxin and anti-toxin. This immunity takes a few months to develop, but it lasts for years. The *Schick Test* enables a doctor to tell whether a child is immune to diphtheria or not, and if this test is repeated once a year it is possible to give a child complete protection against this disease. Notice that this toxin-anti-toxin treatment causes *your body* to produce anti-toxins capable* of destroying the disease germs. When the body becomes immune in this way by producing its own antibodies, it is said to have acquired* *active* immunity.

Measles

The actual organism which causes *measles* has not yet been isolated. It is something that passes through the finest filters—smaller than any known bacteria—and it is called a *virus*. Measles attacks children more frequently than adults and is usually spread by droplet infection or by actual direct physical contact with a case of measles. About fourteen days after infection, the patient develops what appears to be a bad cold, with a running nose, red and watery eyes, a slight cough, and a rise in temperature. This early stage is the most infectious. On the third or fourth day of the cold, red spots appear on the skin, first on the face and behind the ears, and the spots then spread to the neck and other parts of the body. These spots fade away after a few days as the patient recovers, but he is still infectious for another ten days.

Measles itself is not a very dangerous disease, but the patient needs careful nursing if dangerous after-effects are to be avoided. Measles sometimes leads to *bronchitis* (inflammation of the lining of the windpipe), and to *pneumonia* (inflammation of the lungs [1]). If there are discharges* from the ears there is a danger of ear-disease and deafness. Owing to the long delay between infection and the appearance of the outward signs of the disease, and the very infectious stage before the spots appear, measles is a very difficult disease to prevent or control.

One attack of measles causes the body to produce substances (antibodies) capable of destroying measles germs, and these antibodies remain in the body throughout life and make it *immune* to measles.

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[1] Any germ (e.g. measles or influenza) that multiplies in the lungs may cause pneumonia, but most cases, where pneumonia does not follow another disease, are caused by pneumonia bacteria.

Since the body becomes immune by producing its own antibodies, we say that it has acquired *active* immunity.

Whooping-cough

This is another very infectious disease which mainly affects young children. Whooping-cough is spread by droplet infection, and, as in the case of diphtheria, the risk of infection is increased by the existence of 'healthy carriers' of the germ. Between one and two weeks after infection, the patient develops what seems to be an ordinary cold and slight cough, and this early stage is the most infectious. It is not until about ten days later that the long attacks of coughing begin, each attack ending with the characteristic 'whoop' as air rushes into the empty lungs. As with measles, whooping-cough itself is not dangerous if the patient is carefully nursed, but it is the after-effects that may be serious. If the coughing is very violent and lasts for a long time, the lungs may be damaged, thus causing the risk of pneumonia or consumption, which may kill the patient.

A patient suffering from whooping-cough can infect others for a period of six weeks. Owing to the very infectious stage before the characteristic 'whooping' begins, whooping-cough is a very difficult disease to prevent or control. One attack of whooping-cough usually makes the body actively immune to further attacks.

Smallpox

In some tropical countries, smallpox is one of the most dangerous diseases, sometimes killing more people than cholera, plague, and dysentery combined. But in countries where *vaccination* is the rule, smallpox is very rare. The germ of smallpox has not yet been isolated, but it is believed to be a *virus*. Smallpox is one of the most infectious of all diseases. The germs are present in the lining of the patient's mouth, throat, and nose, and are scattered by the spray of droplets during sneezing and coughing. Besides this, germs are also present in the skin, and as dead scales of skin may float about in the air the germs can be carried over long distances in this way. Hence, smallpox is one of the few diseases which are truly 'airborne'. (Most of the diseases that used to be called 'airborne diseases' are spread by droplet infection.) This makes smallpox extremely infectious, and if an unvaccinated person merely enters a room in which a smallpox sufferer is present, he is almost certain to be infected. Smallpox germs can remain dry for months without being killed; in this way clothing, books, papers, &c., remain infected for a long time.

About two weeks after infection, the patient develops headache, backache, and a rapid rise of temperature. Two or three days later, the typical smallpox spots or 'pocks' appear on the face, hands, and feet. These are small hard 'pocks', and feel like small shot under the skin. They soon fill with pus* and become surrounded with an inflamed ring. The patient has high fever for several days, and many smallpox cases die at this stage. If the patient recovers, the skin is 'pock-marked' for life.

After recovery, a smallpox patient must be isolated until all the scales of dead skin have disappeared from around the 'pocks'. This takes from three to four weeks. The patient is then immune to further attacks.

Smallpox can be almost entirely prevented by *vaccination*, which prevents people from catching the disease, or, if they do catch it, from having a severe attack. Vaccination consists of introducing the germ of a similar but milder disease—*cow-pox* (or *vaccinia*)—into human beings. Vaccination was introduced by an English doctor named Jenner, in 1798. He noticed that those who worked among cows often suffered from a mild disease—cow-pox—which they caught from the cows. He noticed, too, that people who had suffered from cow-pox very seldom caught smallpox, which in those days was a very common disease in England. He then carried out experiments on *vaccination*, introducing liquid from cow-pox spots into human beings, and it was found that these vaccinated people became protected from smallpox infection. Nowadays, the *vaccine lymph* used for vaccination is obtained from healthy calves* or from unhatched chicken embryos and is carefully prepared and tested so that it is free from bacteria.

In countries where everyone has to be vaccinated, smallpox has been almost rooted out. If a person is re-vaccinated every few years, he is almost completely protected against smallpox.

Chicken-pox

Chicken-pox is a different and much milder virus disease, which attacks mainly children. It is usually spread by droplet infection, or by direct personal contact. About two weeks after infection, spots appear, mainly on the trunk, and these soon turn into watery blisters which become covered with a crust* and dry up in a few days. The patient is still infectious until all the crusts have fallen off and all the sores have healed up. Although chicken-pox is only a mild disease, all cases should be reported to a doctor, because a mild case of smallpox may be mistaken for chicken-pox and thus produce severe smallpox in others. Since chicken-pox very seldom attacks adults, anything that looks like chicken-pox in an adult should be treated with the respect due to smallpox, i.e. a doctor must be called in *at once*. Vaccination does not protect against chicken-pox.

Tuberculosis and consumption

John Bunyan (1628–88), who wrote *The Pilgrim's Progress*, called tuberculosis 'Captain of the Men of Death', and this disease still remains one of Man's worst enemies, because it is commonest and most fatal between the ages of fifteen and forty-five, which should be the best and most useful years of a man's life. Tuberculosis, also, may attack almost any organ and tissue of the body, although the commonest form is *tuberculosis of the lungs*, which is called '*consumption*'. Domestic animals also may suffer from forms of tuberculosis, although the disease is rare in sheep and goats.

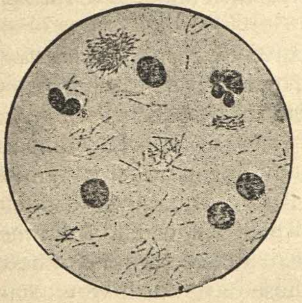

FIG. 15.—Tubercle bacteria (highly magnified)

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Tuberculosis is caused by *tubercle bacteria*, discovered by Koch in 1882. By special staining methods, the germ of tuberculosis can be definitely recognized under the microscope (see Fig. 15). Before anyone can become infected with tuberculosis the *tubercle bacteria* must enter the body. There are two main ways in which it can be carried: (i) *along with the air during breathing*, or (ii) *along with food and drink*. When a consumptive person coughs or sneezes, unless he takes special care, anyone within a few feet of him may breathe in some of the droplets containing millions of tubercle bacteria. Another mode of infection is by breathing infected dust. When a consumptive person spits, the sputum* contains millions of tubercle bacteria. (Laboratory tests on sputum lying in the streets of one tropical city showed that tubercle bacteria were present in 4 per cent. of cases.) If this sputum is allowed to dry up, it may be carried about as dust. Dried sputum from a consumptive person may remain infective for twenty weeks, even when mixed with dust and exposed to sunlight. In damp, dark places tubercle bacteria may survive for as long as a year. This infected dust may be breathed in by healthy people or may fall on foodstuffs. It may even be carried by insects, and living tubercle bacteria have been found in or on house-flies fifteen days after contact with infected sputum. For this reason, spitting in public places is forbidden by law in some countries.

The germ of tuberculosis sometimes enters the body by way of the food-canal, along with infected food and drink. Cows often suffer from a form of tuberculosis, and as the germs pass out with the milk, this infected milk is dangerous. The meat of such an animal will also be infected. For this reason, careful inspection* and control of tuberculous milk and meat is carried out by public health authorities.

The chief ways in which the spread of tuberculosis can be prevented are: (i) *By increasing the power of resistance to infection* by plenty of suitable food, plenty of fresh air and sunshine, and good conditions of housing and living. People in good health, living under good conditions, need have little fear of infection. (ii) *By preventing the spread of infection.* The germs of the disease are usually in the patient's lungs, and he can spread them if he spits or coughs or sneezes without proper care. Hence careless spitting should be strongly discouraged, and anyone suffering from consumption should always spit into a special vessel containing disinfectant* or into paper handkerchiefs which can be burnt. He should also keep his own feeding-vessels separate from those of other people, being particularly careful that they are washed separately.

The great danger about tuberculosis is that a patient may be infected for a long time without showing clear signs of the disease—merely having a slight cough and a tired feeling. Yet it is at this early stage that there is the best chance of curing the disease. But by the time that most cases are brought to the notice of a doctor, the disease is far advanced. The patient has a severe cough and spits in an effort to clear his lungs. He readily becomes short of breath, his temperature rises each evening and he sweats in the night. He gradually loses his appetite, suffers from indigestion, and steadily loses weight.

When the disease reaches this advanced stage it can often be checked, but it can seldom be completely cured.

The most important remedy in the treatment of tuberculosis is *complete rest*, and in some cases surgical* methods are used to rest the diseased lung itself.

Since tuberculosis is such a difficult disease to cure, it is all the more important to take every possible step to *prevent* it. One of the most powerful weapons in fighting the spread of tuberculosis is *education* in healthy living. The disease is always associated with bad housing conditions, over-crowding and under-nutrition. One of the most remarkable things about tuberculosis is that Man has a natural resistance to the disease and that repeated heavy doses* of infection are necessary to overcome this resistance. Nearly everyone is infected by tubercle bacteria some time or other, but only a small proportion of such people actually suffer from tuberculosis, because if the first infection is by a relatively small number of tubercle bacteria it is overcome by the body's natural resistance, and subsequent* light infections stimulate the formation of additional 'acquired resistance', until such a person becomes almost immune to quite large doses of tubercle bacteria. So there is little danger from occasional chance meetings with tuberculous people or from being near them out-of-doors or in well-ventilated rooms (where any germs are well diluted with fresh air). The great danger lies in getting so large a dose of tubercle bacteria as to overcome one's natural and acquired resistance.

A promising method of protecting people from tuberculosis is by vaccination with B.C.G. (Bacillus Calmette Guerin), which is a harmless variety of the tubercle germ, and in some countries B.C.G. is given to all school-children who have never been infected with tuberculosis. By applying a simple and harmless skin reaction,* the *Tuberculin Test*, a doctor can tell whether a person has ever been infected with tubercle bacteria. If this tuberculin test is positive, an X-ray examination will show whether there are any signs of active tuberculosis, or whether the patient's natural or acquired resistance has succeeded in overcoming the infection. If the tuberculin test gives a negative result, then the person can be given B.C.G. to produce, after some weeks, a strong resistance to tuberculosis. B.C.G. vaccination, therefore, can give artificial protection where it is most needed, among people who have not already built up some natural protection and who are likely to be exposed to tuberculous infection, e.g. school-children, infants* living with tuberculous parents, hospital staffs, and medical students.

Tuberculosis is largely a disease of towns and cities and it is much less common among people living in the open country. This fact gives rise to special danger when country people go to live and work in crowded towns and are suddenly exposed to mass infection before they have had a chance to build up their resistance gradually as a result of small doses of infection, sufficient to give protection but not enough to cause the disease.

Sore throat

Most people regard a sore throat as unimportant, but most sore throats are infectious and may be the beginning of more serious diseases, e.g. diphtheria. Hence, every child with a sore throat should be seen by a doctor.

The common cold

The common 'cold in the head' is not caused merely by cold conditions but by infection with a germ or virus. When the germs multiply in the lining of the nose and throat they produce inflammation, and we say that the patient 'has a cold'. Colds are usually spread by droplet infection and sometimes by breathing infected dust. The spread of the infection can be prevented by the same methods used against other 'airborne' diseases, and also by avoiding dust and draughts,* exposure to cold and wet, and rapid changes of body-temperature, e.g. by sitting lightly clothed in a current of air after taking vigorous exercise. The danger of colds is that they weaken the patient's resistance to infection by other more dangerous diseases; so a cold must never be neglected.

Also, some more serious diseases begin with what seems to be a common cold. Immediate home treatment will usually prevent such complications, and the patient should rest (in bed, if possible), drinking plenty of liquid, and sleeping under a blanket to encourage sweating. A drink of hot water containing lime-juice, before going to sleep, will help to make you sweat. Do not take any other medicine unless ordered by a doctor. If you 'catch cold' frequently, you should consult* a doctor.

Influenza

Influenza is an extremely infectious virus disease which spreads from the sick to the healthy by droplet infection in coughing or sneezing. The world-wide outbreak in 1918 killed 18,000 people in London alone; in India 6,000,000 died of influenza. In fact, more people died from influenza than were killed during the 1914–18 World War.

A few hours after infection, the patient develops headache, aching pains in the back and legs, and a high temperature. He should consult a doctor at once. One type of influenza attacks the nose, throat, and lungs like a common cold. Another type attacks the food-canal. A third type attacks the nervous system. The second and third types of influenza are like dengue (see p. 86) in their outward signs. An influenza patient should go to bed at once and try to avoid infecting others when coughing, sneezing, or spitting. To lessen the risk of infection, healthy people should avoid overcrowding and lack of ventilation. People that refuse to 'give in' to a cold or to 'flu and try to carry on as usual are a danger to themselves and to the community. The quickest way to get better is to rest in bed, and this is also the best way to isolate the patient and thus prevent him from infecting other people. The handkerchief, if properly used to cover sneezing and coughing, may help to prevent droplet infection. But once a handkerchief is covered with infected *mucus* from the nose and air-passages it becomes dangerous. It infects the hands of the user and he infects everything else he handles. Every time the infected handkerchief is pulled out of the pocket and waved in the air it infects its surroundings. A good arrangement is to use paper handkerchiefs, which can afterwards be burnt or thrown down the sewer.* The hands of a person suffering from any respiratory disease need to be washed even more frequently than usual.

Respiratory diseases are often spread by using drinking-cups and eating-vessels which have previously been used by a sick person. In public and communal eating-places, eating-vessels should always be washed with *boiling* water to prevent the spread of infection.

CHAPTER 4

HYGIENE OF THE BLOOD SYSTEM

The blood system is concerned with *transport*. It carries the necessities of life—food, water, and oxygen—to all parts of the body. It carries food from the intestine and oxygen from the lungs to the body-tissues and it removes waste products. It distributes heat produced in working muscles and so regulates the temperature of the body. By the action of its white cells and certain complex* chemical substances, the blood forms a defence against infection.

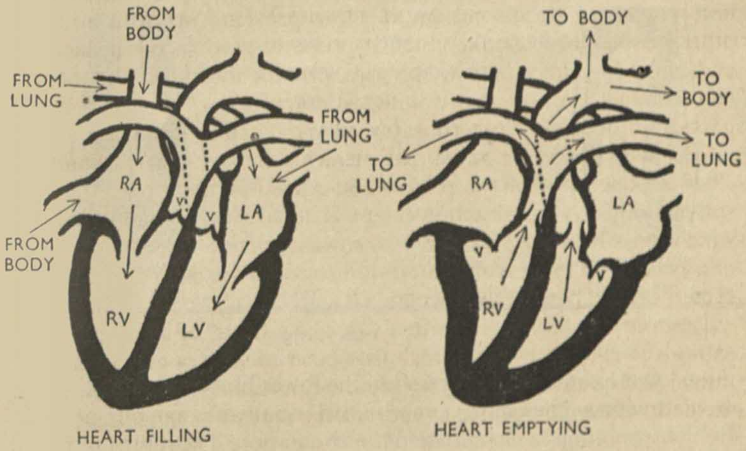

FIG. 16.—Action of heart (diagrammatic)

RA: right auricle
RV: right ventricle
LA: left auricle
LV: left ventricle
V: valve

With a sufficient and suitable diet and a healthy digestive system, the blood receives the necessary food for distribution. With a plentiful supply of fresh air and proper breathing, the blood gets the necessary oxygen. The next thing is to ensure an efficient *circulation*. The heart pumps blood through the main artery and its branches until it reaches the capillary blood-vessels. By the time the blood reaches the capillaries the pumping action of the heart is no longer felt and the blood pressure in the capillaries is much lower than in the larger arteries. The blood is collected from the capillaries by the veins and returned to the heart. *This blood is not forced back through the veins by the pumping action of the heart but by the movement of the body-muscles and the diaphragm.* When the muscles shorten and thicken they press upon the veins and, owing to the valves* in the veins, the blood is driven towards the heart (see Fig. 17). If we stand perfectly still for a long time, we become very uncomfortable and may even faint. This is because, without muscle movements, the blood collects in the veins of the lower part of the body and in the lower limbs, thus making the circulation less efficient. In practice, we usually change our position slightly from time to time to help the circulation. The return of blood to the heart is also helped by the movements of breathing. In Book III we have seen that the ribs are raised forwards and upwards, while the diaphragm contracts and flattens. The chest-cavity is thus enlarged, but at the same time the abdominal cavity is made smaller. This pressure on the contents of the abdomen forces blood from the large veins up to the right side of the heart. When air is breathed out from the lungs, the greater pressure in the chest-cavity will hinder for a moment this flow of blood to the right side of the heart: but as soon as air is breathed in, the lower pressure in the

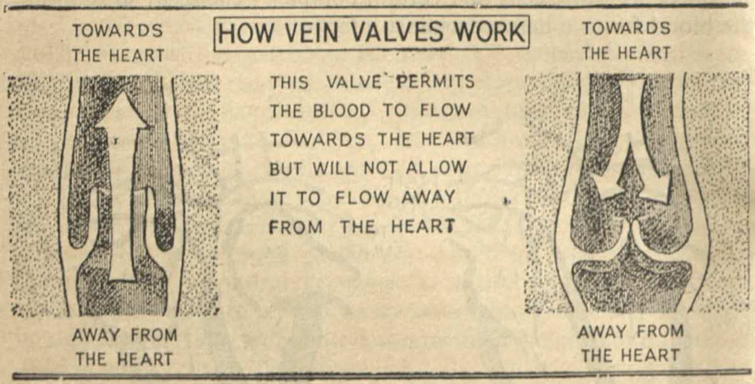
HOW VEIN VALVES WORK
TOWARDS THE HEART
AWAY FROM THE HEART
THIS VALVE PERMITS THE BLOOD TO FLOW TOWARDS THE HEART BUT WILL NOT ALLOW IT TO FLOW AWAY FROM THE HEART
TOWARDS THE HEART
AWAY FROM THE HEART

FIG. 17.—Vein valves

chest-cavity will 'suck' blood into the three main veins leading to the heart.

Breathing movements also help the circulation of blood through the lungs, since, when air is being breathed out of the lungs, the greater pressure in the chest-cavity drives blood along the veins leading from the lungs to the left side of the heart.

The importance of muscular exercise

Without exercise, a man cannot keep up an active circulation of the blood. If a man is kept perfectly still in an upright position (e.g. tied to a post), he dies after a time owing to the failure of his circulation. This happened in the Roman punishment of 'crucifixion', a slow and painful death by hanging a person on a wooden cross. One of the most important effects of active exercise—playing games, walking, running, swimming, cycling, &c.—is that it improves the circulation of the blood, and the more efficient the transport system, the healthier the body and brain will be.

FAINTING AND SHOCK

The main reservoir* of blood in the body is contained in the blood-vessels of the stomach, liver, spleen, and intestines, and this region is so richly supplied with blood-vessels and blood that at any one moment it may have in it from one-sixth to one-third of all the blood in the body. When the walls of these blood-vessels contract, more blood is forced to the brain, e.g. if a man is carefully balanced while lying on a 'see-saw' and then given a problem in mental arithmetic, his head-end overbalances because more blood flows to the brain from the central reservoir. Fainting (or mild *shock*) is caused by an insufficient blood supply to the brain, hence first aid consists in placing the patient with his feet higher than his head and then pressing gently on his abdomen. Suddenly standing upright after lying down quietly for some time may cause momentary faintness because it takes a fraction of a second for the abdominal blood-vessels to contract and prevent blood draining down away from the brain.

Shock is a result of the body's reaction to injury or emotional* upset, when the circulation slows down, thus reducing the oxygen supply to the tissues. After severe injury, there is often a serious loss of fluid from the blood system, so less blood is returned to the heart, which delivers less blood to the main abdominal reservoir and to the extremities of the body (e.g. the brain). The blood pressure falls, the pulse* slows down, and the patient's skin becomes pale and cold. Severe shock is best treated by restoring the lost blood volume. This is done by *blood transfusion,** and hospitals therefore keep a stock of blood in immediate readiness for urgent cases. *Whole blood* is transfused whenever large amounts of blood have been lost through accident, injury, childbirth, or certain diseases (e.g. *anaemia*, a condition in which there is a deficiency of red blood-cells). Blood for transfusion is drawn from a healthy person, a substance is added to prevent clotting, and the blood is stored in a refrigerator at a temperature of from 4° to 6° C. Under these conditions it may be kept for about three weeks. When a patient requires a whole-blood transfusion, he must have blood that matches his *blood-group*. There are four main groups of blood—A, B, AB, and O—and a patient with a group A blood must be given group A blood, a group B patient must have group B blood, and so on. Under certain conditions, however, group O blood may be given to group A or B or AB patients. Mixing blood from the wrong groups causes the red blood-cells to cluster* or clump* together, and this may have fatal results. So before a blood transfusion is given, samples of the patient's and the donor's* blood are first mixed under a microscope to see that the red blood-cells do not clump.

Plasma (the liquid portion of blood from which the blood-cells have been removed) can be dried or frozen and thus keeps better than whole blood. This plasma is often used instead of whole blood for replacing fluid lost from the blood, e.g. in accident cases out of reach of a hospital and for treating shock resulting from severe burns. Since plasma contains no blood-cells, it does not need to be matched with the patient's blood.

Blood transfusions now save so many lives that the supply of human blood for medical use has become an important branch of public health. But blood cannot be made artificially; the only source of supply is human veins. So every healthy citizen should be willing to give a little of his blood to his local 'blood bank', ready to save a fellow-citizen's life. Most people can spare a pint of blood without any discomfort or ill-effects; this pint of blood can mean the difference between life and death to a fellow-citizen.

The blood circulates in a closed system of tubes—the blood-vessels. If a blood-vessel is cut, the blood escapes, and if the damaged blood-vessel is large, the loss of blood may be serious.

With small cuts and scratches where only small blood-vessels have been damaged, bleeding soon stops owing to the clotting of the blood as it comes into contact with the air. Although there is no danger from loss of blood in such cases, there is always a danger that harmful bacteria may enter the wound, so even the smallest wounds should be treated with an *antiseptic** (e.g. weak iodine solution, which stops the growth of bacteria) and then covered with clean cotton cloth to keep out infected dirt. Moderate bleeding is a safeguard against infection, since the blood washes away germs. Dirty wounds should be washed with clean water to remove dirt or other foreign bodies.

With larger wounds, the first thing to do is to stop loss of blood. This can usually be done by applying gentle pressure to the wound by bandaging* a pad of clean cotton material over the wound. As soon as the bleeding has been stopped the bandage should be loosened. If bandaging fails to stop the flow of blood, greater pressure must be applied to the damaged blood-vessel. When a *vein* is bleeding (the blood escaping in a dark-red, steady stream) pressure should be applied with the thumbs to the side of the wound which is *farthest away from the heart*. Bleeding from veins is more frequently met with than bleeding from arteries, the veins being nearer the surface of the body than the arteries. The blood-pressure in the veins being only small, bleeding from a vein is easier to stop than bleeding from an artery.

Bleeding from an artery is more serious, but as the arteries are protected by the muscles, arterial bleeding is not often met with. In bleeding from a large artery, bright-red blood escapes in pulses as the heart beats, and immediate treatment is necessary. In arterial bleeding, pressure should be applied with the thumbs to the side of the wound *nearer the heart*. If the wound is in the arm or leg, and the pressure of the thumbs is not sufficient to stop the bleeding, a *tourniquet* may be used. This is made by tying a bandage round the limb above the point where the thumb is pressing, and tightening it by twisting with a stick. A hard pad is put under the bandage so as to press on the artery where it passes over a bone. The proper use of a tourniquet should be learnt from a doctor by attending a first-aid course, and it is important to remember that *a tourniquet is only used in very serious cases, when a doctor should be called at once. A tourniquet stops blood circulation in the limb, and must not be kept tight for more than fifteen minutes at a time.*

PUS-FORMING BACTERIA—BLOOD-POISONING

The skin separates the interior of the body from the outside world. When the skin is cut or broken, germs can enter, and some of these are harmful.

The commonest germs which enter the skin in this way are the bacteria which form *pus*. The tissues themselves are able to resist invasion by bacteria, for the white corpuscles in the lymph surround and destroy the invading bacteria; but if the invaders are too numerous the white cells die and mix with dead bacteria and decomposing body-cells to form *pus* (see Fig. 18). Sometimes these pus-forming bacteria may enter a hair-pit or a sweat-duct and, if they are sufficient in number, they form a *pimple*. If the bacteria make their way deeper and multiply more rapidly, they form a *boil*. If the pus-forming bacteria get into the blood-vessels they may be carried to other parts

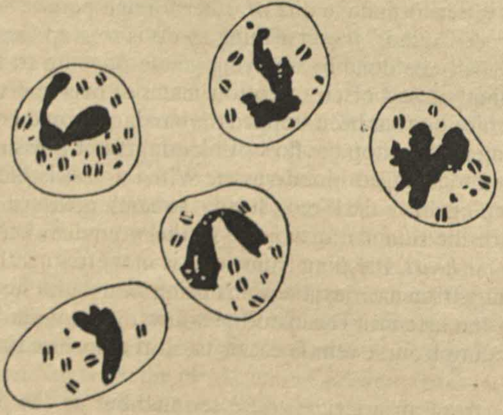

FIG. 18.—White blood-cells which have absorbed disease germs

of the body, causing *blood-poisoning*, which is often fatal. It is important to remember that most cases of blood-poisoning result from neglected sores, cuts, and scratches, often very small in size. To avoid infection with pus-forming bacteria, first see that any wound is *clean*. The pain caused by cleansing a wound is small compared with the pain caused later by an infected wound. The person giving first aid should first wash his own hands and then wash the wound with a *clean* piece of cloth and *clean* water. Better still, wash the wound with a little *germicidal* soap* or with a *mild antiseptic*, e.g. 'Dettol' or dilute sodium hypochlorite solution ('Milton'). Then bandage the wound loosely, so that air can get to it. It is very important to avoid spreading the bacteria contained in pus from sores, pimples, and boils, which should never be squeezed to get out the pus (particularly if the infection is near the lips, nose, eyes, or ears when the infection may be spread to near-by organs).

Tetanus—Lockjaw

Besides pus-forming bacteria, *tetanus* bacteria may enter wounds, causing a very dangerous disease, *tetanus* (or *lockjaw*). Normally, tetanus bacteria live and multiply in the intestines of grass-eating animals, but without doing any harm to the animal. Some tetanus bacteria pass out with the faeces, hence the earth where such animals are kept, or cultivated soil to which animal manure has been applied, usually contains tetanus spores.* Tetanus spores are a highly resistant form of tetanus bacteria which can survive unfavourable conditions for many years and still retain their ability to germinate. When the skin is broken by any dirty object (e.g. a dirty wooden splinter or a rusty nail) tetanus spores may enter. Since tetanus bacteria grow best in the absence of air, a deep hole in the flesh, which does not bleed and soon closes up, is more likely to be dangerous than a clean, open wound that is washed by bleeding and which is open to the air. Under suitable conditions, the tetanus bacteria divide and multiply rapidly, producing a very poisonous *toxin* which acts on the nervous system, first causing stiffness of the muscles of the neck and jaws. Later, the muscles of the neck, jaws, and face contract and become fixed, so that the mouth cannot be opened—hence the name '*lockjaw*'. Finally, all the muscles of the body become stiff and the patient dies.

To guard against tetanus infection it is particularly important to *clean all dirty wounds at once*. Mere wetting with a weak antiseptic will have no effect on highly resistant tetanus spores: thorough cleansing is the best safeguard. It is always risky to seal up a dirty wound with sticking-plaster,* but it becomes highly dangerous if there are tetanus germs in the wound. The wound should be bandaged lightly, so that air can get in.

Deep-pierced* wounds require particularly careful treatment and should be examined by a doctor, who will inject a preparation of tetanus anti-toxin, when advisable, to prevent infection. (In wartime, every wounded soldier is given an anti-tetanus injection at the earliest opportunity, however slight his wound, since gunshot wounds are particularly dangerous as a source of tetanus infection.) There is also a method for producing active immunity by injecting tetanus *toxoid*, but this injection has to be given several weeks *before* exposure to tetanus infection. Whenever there is stiffness of the head and neck within three weeks of receiving a dirty wound, a doctor should be consulted* at once. If an anti-tetanus injection is given in the early stages, the disease can be cured.

Snake-bite

A bite from a poisonous snake shows two wounds a short distance apart where the poison-teeth entered (see Fig. 19). (Non-poisonous snakes sometimes bite, but leave more numerous marks made by *rows* of teeth without the *pair* of larger punctures* which are characteristic of poisonous snakes.) There are two main kinds of snake-poison. One kind, produced by snakes of the *cobra* group (e.g. Krait, Mamba), affects mainly the nervous system, and its effects are sometimes slow to appear, especially if the bite is on a leg. The other kind of snake-poison, produced by snakes of the *viper* group (e.g. Russell's viper, fer-de-lance), usually affects the part of the body near the bite, where a burning pain usually develops within a few minutes. If the snake can be killed and shown to the doctor treating the patient it will help him to decide on the best treatment.

Treatment for snake-bite must be immediate, and, if possible, a doctor should be called at once, the victim being kept as quiet as possible in the meantime. The first thing to do is to remove as much of the poison as possible from the wound and stop it from getting into the blood-stream and poisoning the whole body. If the bite is on the leg or the arm, the limb must be *ligatured*, with a strong rubber band or bandage tied tightly, like a *tourniquet*, immediately above the bite, i.e. between the bite and the heart. (The tourniquet must not be so tight that the pulse is stopped and it should be loosened for a few minutes every quarter of an hour and retied again a little farther from the wound.) The next step is to remove as much as possible of the poison remaining near the bite. This is done by cutting open the flesh round the bite so that the poisoned blood flows freely. Two half-inch cuts, in the shape of a cross (+), and as deep as the snake-bite punctures, will let poisoned blood escape. After first-aid treatment has been applied, and if there is no doctor on the spot, the patient should be *carried* to the nearest hospital or dispensary as soon as possible.

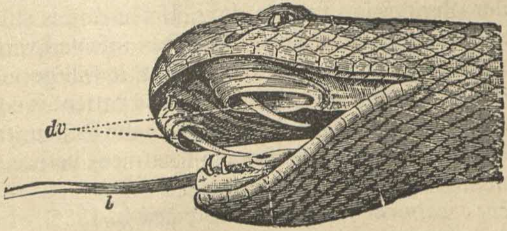

FIG. 19.—Head of poisonous snake

dv—poison-teeth. l—tongue

Scorpion stings inject a poison which affects the nervous system like cobra-poison, but it is much less dangerous and seldom causes death. Treatment should be given as for snake-bite, cutting open the wound with a clean sharp knife or razor-blade so that it bleeds freely. A few large spiders have poisonous bites, and similar treatment can be applied to get rid of as much poison as possible from the wound. Centipedes inject a different kind of poison, and bathing the wound with weak ammonia solution usually relieves the pain.

Rabies—hydrophobia

Rabies is a disease of mammals, and a man becomes infected with the disease if he is bitten or scratched by an animal suffering from rabies —usually a mad dog. (A rabid animal often scratches its mouth to remove saliva and thus infects its claws: hence the danger from scratches—as well as from bites.) The outward signs of the disease do not develop for a long time—from three to eight weeks after the bite—and if the *Pasteur treatment* is given before signs of the disease appear, the patients rarely get rabies. In countries where rabies is common, any dog-bite must be reported immediately to a doctor. The doctor thoroughly cleans the wounds and tries to destroy any germs that may have entered. He then has to decide whether the Pasteur anti-rabies treatment is necessary. If the dog cannot be traced, or if the dog is dead, he assumes that it was mad and infected with rabies and the treatment is given. If possible, the dog should be caught alive and unhurt and handed over to the health authorities to be kept under observation for ten days. If the dog is still alive and *well* at the end of this period, then it was not infected with rabies. If the dog was infected before it bit the patient, it will go mad and die in a few days, and the Pasteur treatment of the patient is necessary. In any case, it is known within ten days whether the Pasteur treatment is advisable, and there is still time for the treatment before the disease can develop.

The *Pasteur treatment* was first introduced in 1885, when Pasteur found that the *rabies virus*, contained in the spinal cord of a mad dog, could be gradually weakened in the laboratory until it no longer caused death. The patient receives an injection of the weakest virus; then, day by day, he receives injections of stronger and stronger virus, until, after two or three weeks, the patient's resistance to the disease is so increased that he becomes *immune*, and can resist the strongest virus from a mad dog.

The best way to control rabies is to control the disease in dogs. A dog can only get rabies if it is bitten by an infected animal, usually another mad dog. Hence if all the dogs in a large area are *muzzled** for a sufficient period each year, no dog can be infected, and if all the dogs entering a country are kept in strict quarantine* for several months, rabies cannot be introduced. Rabies has been rooted out from England in this way.

DISEASES CARRIED BY BLOOD-SUCKING INSECTS

Many diseases are caused by the invasion of the blood-stream by tiny parasites: e.g. malaria, filariasis, dengue, yellow fever, plague, typhus, and sleeping-sickness. The main way in which these blood-parasites are carried from the sick to the healthy is by blood-sucking insects.

For example, *mosquitoes* carry the germs of malaria, filariasis, dengue, and yellow fever; a *flea* carries the germ of plague; a *louse* carries the germ of one form of typhus fever; a *mite* carries the germ of Japanese river-fever (scrub-typhus); a biting *fly* carries the germ of sleeping-sickness.

MALARIA

Until quite recent years, malaria was considered to be the most wide-spread disease in the world, and besides causing millions of deaths every year directly and indirectly, it was also the chief obstacle* to progress and development, because millions of people were so weakened by malaria that they could not live happy and useful lives. Recent discoveries, however, have greatly reduced the threat of malaria to mankind, and ultimate* victory over the disease is now in sight. Malaria has already been completely rooted out from several communities where sufficient money and organizing ability were available for this purpose.

The story of malaria forms such an important example of Man's conquest of disease that we must outline it here.

Malaria is known to have been one of the most serious human diseases for over 2,000 years, but nothing was known of how it was caused or how it could be controlled until more recent times. The first step towards the *control* of malaria was made in the seventeenth century, when it was found that an extract of *cinchona bark* (which contains *quinine*) could *cure* the disease. But nothing was known of its *cause* until as recently as 1880, when the French colonial doctor Laveran discovered the *malaria parasite* in the red blood-cells of one of his malaria patients. During the next few years Italian doctors traced nearly all the stages through which the parasite passes in human blood, but *how the parasite entered the blood* was still unknown. About 1895, Manson (the British doctor who had discovered that the *Filaria* parasite was carried from man to man by mosquitoes) suggested to Ross (a British army doctor in India) that malaria might be carried in the same way, and Ross soon found the parasites of *bird-malaria* in the stomach wall of a female mosquito which had sucked blood from an infected bird. In 1896, Ross discovered how the parasites that cause bird-malaria pass from the mosquito's stomach into its salivary glands, ready to enter the next bird bitten by the infected mosquito. This completed the life-history of the malaria parasite in birds and suggested that human malaria might be transmitted in the same way by mosquitoes. The work of Ross was soon followed up in Italy, where two Italian doctors proved that human malaria was transmitted by mosquitoes, and it became clear, at last, that if there were no mosquitoes there would be no malaria.

This discovery that mosquitoes carried disease was soon applied to *mosquito-control*, e.g. in Central America, where de Lesseps (who made the Suez Canal) had been compelled to give up work on the Panama Canal, in 1881, because of disease among the workers. The Americans afterwards re-opened and completed the plan with the aid of mosquito-control.

The next forward step was the discovery that only *Anopheles mosquitoes* carry human malaria and that only a few species* of anophelines are of practical importance. This greatly simplified the problem of mosquito-control, because each species of malaria mosquito favours a special type of breeding-place and has its own particular feeding-habits.

Life-history of malaria parasite

Although both male and female anophelines feed on plant-juices, the female *Anopheles* has to suck blood if her fertilized eggs are to develop, and as she digests the blood, her eggs develop. To obtain this blood, the beak and its needle-like mouth parts are forced through the victim's skin. Liquid from the insect's *salivary glands* is then squirted into the wound to stop the blood from clotting and to break up the red blood-cells, which are too large to pass through the insect's beak. Then the blood is sucked up and passed into the insect's 'stomach'. If the victim is suffering from *malaria*, his blood contains microscopic, one-celled *malaria parasites* (Fig. 20) and some of these are sucked up with the blood and enter the insect's 'stomach' (see Fig. 20). Here, a number of changes take place, and very small,

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The top diagram shows a female *Anopheles* feeding on a man with malaria and taking in blood containing both male (♂) and female (♀) malaria parasites.

The centre diagram shows how these male and female malaria parasites unite in the mosquito's 'stomach' to produce a single egg-like body which develops in the wall of the 'stomach', producing large numbers of small, needle-shaped parasites which make their way to the insect's salivary glands. This stage of development of the parasite inside the mosquito takes at least a week.

The bottom diagram shows the same mosquito feeding again on a man after the above stage of development is complete. She is injecting the needle-shaped parasites into the human skin, and within half an hour they will make their way to the liver where they develop for another week before returning to the blood-stream and entering red blood-cells.

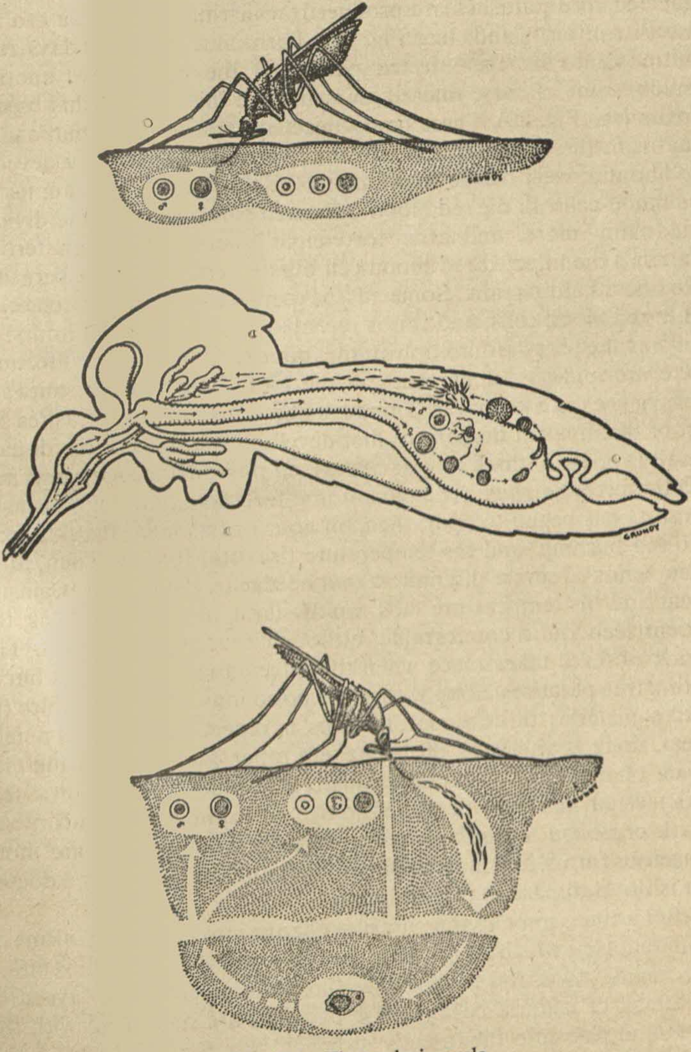


FIG. 20.—The malaria cycle

Diagrammatic. The sizes of the parasites and mosquitoes are not in proportion to each other
(For explanation, see foot of opposite page)

needle-shaped parasites are produced, which make their way to the insect's salivary glands (see Fig. 20). Then, nine to twelve days after the mosquito bit the infected patient, if the insect bites another person, some of these malaria parasites are injected into his blood-stream (see Fig. 20). These newly-injected parasites soon make their way from the blood-stream into the liver-cells, where they develop for about a week before returning to the blood-stream and entering red blood-cells. In the red blood-cells each parasite grows and divides into many more, and after forty-eight hours (in 'benign tertian malaria') the infected red blood-cell bursts, setting free the parasites into the blood-stream. Some of the parasites succeed in entering other red blood-cells, and this is repeated every forty-eight hours. In this way the parasites multiply until, about 10–14 days after infection, there are millions of parasites in the blood and the first outward signs of the disease appear. There are about one million parasites per c.c. of blood when these signs first develop. The signs of the disease usually appear in three stages: (i) the *cold stage*, (ii) the *hot stage*, and (iii) the *sweating stage*. The patient first feels cold (although his temperature has begun to rise); then, an hour or two later, his skin feels hot and burning, and his temperature rises still further. Then, after a few hours of severe discomfort and headache, the patient begins to sweat and his temperature falls rapidly until, a few hours later, the patient feels quite comfortable, although tired and worn-out. The attack of fever takes place when the infected red blood-cells burst, setting free parasites along with some poisonous substance. Since (in tertian malaria) this course of events is repeated every forty-eight hours, there is an attack of fever every other day. (*N.B.* In the *first* attack of malaria, the fever is usually continuous for the first few days.) What has been described above is a simple, straightforward attack of *benign tertian* malaria*, but unfortunately there are more dangerous forms, and malaria should therefore be treated by a doctor —it is not a disease to regard lightly.

After a time, some of the parasites change into larger organisms of a different type which do not produce fever, and if the patient is bitten by a female *Anopheles* at this stage (i.e. from seven to ten days after the attack of malaria began) these parasites are sucked up with the blood and pass into the insect's 'stomach' (see Fig. 20).

The life-history of the benign tertian malaria parasite, therefore, is very complicated and occupies about thirty days, consisting of two distinct stages, (i) in the human body (twenty-one to twenty-four days), and (ii) in the mosquito's body (nine to twelve days). You will notice that in order to pass on the malaria parasite, a female *Anopheles* must seek a second blood-meal nine to twelve days after picking up parasites at her first blood-meal.

There are four different species of malaria parasite affecting man, producing four different kinds of malaria, the following three species being the most important: (i) *Plasmodium vivax* is the one-celled, microscopic parasite that causes *benign tertian malaria* with attacks of fever about every forty-eight hours. It was called *benign** malaria because this disease seldom kills the patient. (ii) *Plasmodium falciparum* is the germ of *malignant* tertian* (or *sub-tertian*) *malaria.* The attacks of fever recur* about every forty-eight hours (as with benign tertian), and this disease is more often fatal. (iii) *Plasmodium malariae* produces *quartan malaria*, a relatively mild disease with the fever recurring about every seventy-two hours. As these different types of malaria require different curative treatments it is particularly important that expert medical advice should be sought early in all cases of recurrent fever.

The prevention of malaria

The old saying 'Prevention is better than cure' is even truer of malaria than of any other disease, because although it is possible to cut short an attack of the disease, it is extremely difficult to remove all the malaria parasites from the patient's body. In principle, there are three different ways of rooting out malaria: either (i) *destroy all malaria-carrying mosquitoes*, or (ii) *protect everybody from mosquito bites*, or (iii) *destroy all malaria parasites in human beings*. Malaria has been controlled in the past by making use of all three methods, but now that new *insecticides** are available which are very deadly to mosquitoes, the first method has become the most effective.

MOSQUITO CONTROL

Before the discovery of these new insecticides (e.g. DDT) the best way of freeing a district of mosquitoes was to prevent them from breeding. Since the early stages of the life-history are spent in water (see Bk. III), the first step is to see that any suitable collections of water are removed or made unsuitable. Small pools should be filled in and vessels such as old tins, jars, bottles, and coconut shells should be cleared away. Rain-water roof-channels and pipes should not be allowed to bend and hold water, and holes in decaying trees should be filled up with cement. Any open drains for carrying off surface-water should have smooth, sloping sides and should be kept clean so as to give no hold to larvae and to carry off the rain-water as rapidly as possible. Better still are *subsoil* drains* of unglazed* earthenware pipes laid below the surface so that the excess water is carried off underground, out of reach of mosquitoes. (This method is widely used for draining narrow valleys.) Pools which cannot be filled in or drained should be treated with oil. If a thin layer of oil is spread on the surface of the water, the mosquito larvae and pupae cannot breathe, and therefore die. If DDT is added to the oil, then the mosquito larvae are poisoned. Since it takes more than a week for an egg to develop into an adult mosquito, if oil is properly applied at seven-day intervals, breeding is impossible.

In recent years, *permanent control* of anopheline mosquitoes has been carried out over large areas by the use of DDT and similar insecticides, and these new substances have now completely revolutionized anti-malarial work so that it is becoming possible to make a general attack on malaria throughout the tropics. DDT is very deadly to mosquitoes and other insects, and if walls and ceilings of houses are sprayed with a solution or suspension of DDT, after the liquid evaporates tiny crystals of DDT are left behind. When a mosquito rests on the wall and its feet touch the DDT it absorbs a poisonous dose and dies in a few hours. DDT is also used mixed with oil for spraying mosquito breeding-places. In the island of Cyprus, for example, anopheline mosquitoes have been completely wiped out by treating all their breeding-places with DDT. In British Guiana, two of the most dangerous species of anopheline mosquitoes have been wiped out by spraying the inside of every building with insecticide, and malaria has practically disappeared from these areas, which include rice fields and sugar-cane fields, swamps and waterways. This success is being repeated in the island of Mauritius. In Southern Rhodesia, four teams of fifteen men, in one season, almost wiped out malaria over an area of nearly 2,000 square miles by spraying every building with DDT. On farms in this area it was customary for 20–25 per cent. of the labour force to be ill at any one time throughout the wet season. After every hut had been sprayed with DDT every farm was working at practically full strength. Similar results have been achieved* in the Transvaal, in parts of Brazil, in Bombay Province, in Italy, Greece, Venezuela, and the U.S.A. So a disease which has been one of Man's worst enemies for over 2,000 years is at last being conquered.

Protection against mosquito-bites

In areas where anopheline mosquitoes still exist, an important means of preventing the spread of malaria is to *protect people from mosquito-bites*. In some very malarious districts, doors, windows, and other openings in houses are covered with fine wire-gauze* to keep out mosquitoes. This is rather costly (and it also interferes with free ventilation), hence sometimes only a single room is made mosquito-proof, for use after sunset. In any case, everybody living in a district where malaria exists should sleep under a mosquito-net. The net should be put down before sunset and its edges should be pushed under the

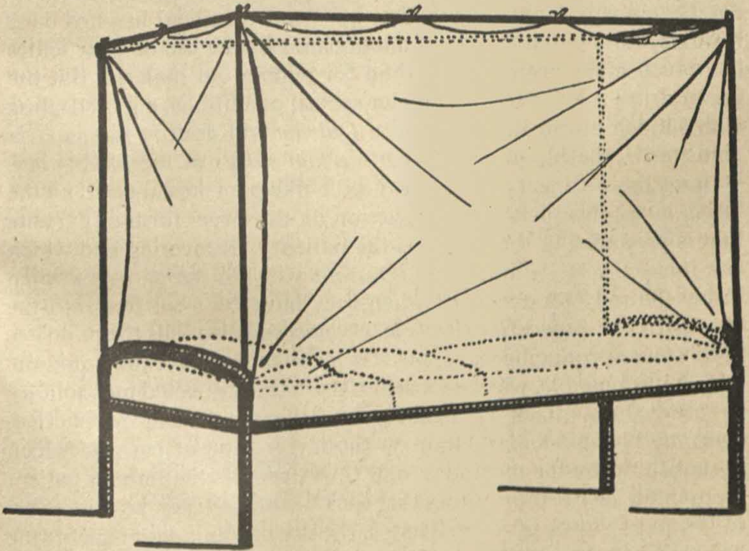


FIG. 21.—Bed with mosquito-net tied inside the frame and tucked under the mattress

bed (see Fig. 21). Long trousers and long sleeves should be worn after sunset in malarious areas.

Most important of all, *any patient suffering from malaria (or getting better from an attack) should stay in a mosquito-proof room or under a mosquito-net*, so as not to infect mosquitoes which may later spread the disease. The greatest care is necessary between sunset and sunrise, when malaria-carrying mosquitoes are most active.

Destruction of malaria parasites

In theory, if every human being infected with malaria could receive proper treatment in the early stages of the disease, malaria could be completely wiped out. In practice, however, this ideal has not been realized and the destruction of anophelines by the use of insecticides is a much more promising method for wiping out malaria. But the use of drugs is still necessary under special conditions, e.g. in dealing with sudden outbreaks of malaria. *Quinine* will destroy the malaria parasites in the blood, *but only at certain stages* of the life-history. Quinine has no effect on the fine, needle-like parasites injected by the biting insect. Neither has it any action on the larger form of parasite that is produced in the blood as the patient is recovering and which can infect the biting mosquito. Quinine will kill the parasites when inside the red blood-cells or when they have been set free into the blood-stream. *Mepacrine* (*Atebrin*, *Quinacrine*) also kills the parasites in this fever-producing stage, but it is much more active than quinine. In fact it is possible, when exposed to the bites of infected mosquitoes, to *prevent* an attack of malaria by taking sufficient Mepacrine. *Pamaquin* (*Plasmoquine*) destroys the larger type of parasite which is sucked up by the mosquito, and thus prevents the human patient from infecting the mosquitoes that suck his blood when he is recovering from an attack of fever. That is, the use of Pamaquin benefits the community. *Paludrine* is a very valuable drug both for preventing and curing malaria. No previous anti-malarial drug had any effect on the malaria parasite at the stage when it is developing inside the liver-cells and before it enters a red blood cell. Paludrine has a great advantage, for if a small dose of it is taken at regular intervals it is possible to prevent development of the parasites before they can produce fever. The proper use of Paludrine, therefore, will keep people free from malaria even when they are exposed to infection in malarious areas. Another drug used for treating malaria is *Chloroquine.*

YELLOW FEVER

In the eighteenth and nineteenth centuries, *yellow fever* was very common in tropical and sub-tropical countries bordering on the Atlantic Ocean, and the disease was much more deadly than malaria. Today, yellow fever is limited to a few small areas in Central and South America and in Africa south of the Sahara. Since yellow fever is so seldom met with, it may seem a waste of time to discuss a disease which is unknown in most countries, but we shall see that there is a serious danger that the disease might be introduced, with terrible results. Yellow fever, like malaria, is passed on by mosquitoes. There are two forms of yellow fever: (*a*) *urban yellow fever*, which affects only Man, and (*b*) *jungle yellow fever*, which is a disease of monkeys sometimes spreading to Man. The two different forms of the disease are transmitted by two different kinds of mosquitoes.

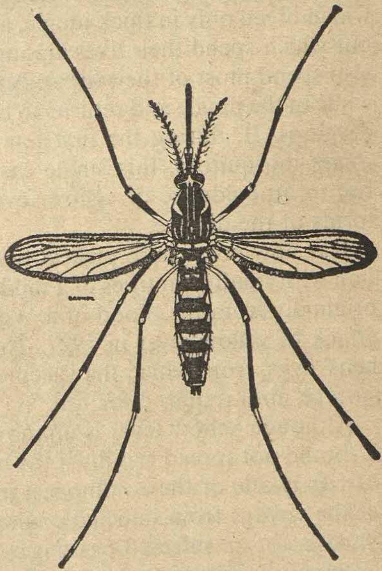


FIG. 22.—*Aëdes aegypti* mosquito (female) (magnified 7 times)

Note the characteristic markings of body and legs

(This mosquito carries yellow fever and dengue)

The carrier of *urban yellow fever* is the very common 'tiger mosquito' (its scientific name is *Aëdes* or *Stegomyia*) (see Fig. 22). This mosquito is easily recognized because its legs and body bear white stripes. *Aëdes* breeds usually in clean water standing in old tins, jars, bottles, roof-channels, and water tanks, while anopheline mosquitoes breed in more natural deposits of water. Hence the 'tiger mosquito' is mainly a town and house mosquito, while *Anopheles* is commoner in country districts. The germ of yellow fever is a very tiny *virus*. When a tiger mosquito bites a yellow fever patient during the first three days of the fever, it sucks up some of the virus, and about a week later the mosquito becomes infectious for Man and remains infectious for the rest of its life. If an infected tiger mosquito bites a man, the yellow fever virus is introduced into his blood, along with the insect's saliva. Between three and six days later, the patient has a sudden attack of fever, lasting three or four days, which is rather like *dengue*. In severe cases the skin and the whites of the eyes become yellow, and bleeding within the body occurs. In many cases the patient dies. If the patient recovers, he is immune for life.

Jungle yellow fever is spread among jungle monkeys in South America and in East and West Africa by other kinds of mosquitoes which breed only in thick jungle, away from most human settlements, but which spend their lives among the tree-tops (where the monkeys also spend most of their lives). A man occasionally becomes infected while in the jungle and returns to his village or town before the disease develops. If, during the first few days of his fever, he is bitten by *Aëdes* mosquitoes, this single case of jungle yellow fever may give rise to an epidemic of yellow fever, for the same virus causes both forms of the disease.

It is now possible to protect people from yellow fever by vaccination with small quantities of a mild type of yellow fever virus obtained originally from the blood of a West African who recovered from an attack of yellow fever in 1927. This special virus is cultivated inside hens' eggs, from which the vaccine is prepared, dried, and frozen for storage until required for use.

Although yellow fever is unknown in Asia, there is no reason why it should not spread rapidly if the infection were once introduced: the carrier is one of the commonest mosquitoes. In the past, the length of the voyage from infected countries has stopped the spread of the disease, for an infected passenger who developed the disease would become non-infectious long before reaching a non-infected country. Today, however, owing to the introduction of rapid travel by air, there is a serious danger that a passenger might be bitten and infected just before leaving West Africa, for example, and then become infectious some seven to ten days later, after he had arrived in a country free from yellow fever but having plenty of tiger mosquitoes. To prevent the spread of yellow fever in this way, all countries have agreed to spray the inside of aircraft with insecticide just before leaving one country and immediately on arrival in another, to keep airfields free from mosquitoes, and to see that all passengers leaving a yellow fever country have been vaccinated against the disease.

FILARIA-WORMS

The commonest of the parasitic filarial blood-worms is carried mainly by female *Culex* mosquitoes which have sucked blood from an infected person (see Fig. 23). The young filaria-worms carried by the mosquito are about 1·5 mm. long, and when the mosquito bites a human being the young filaria-worms enter the skin near the bite and make their way to the lymph-vessels. When fully grown (about 10 cm. in length) these filaria-worms may block some of the lymph-vessels, sometimes causing huge swellings, particularly of the legs and feet, called *elephantiasis*. An adult female filaria-worm produces vast numbers of small, thread-like embryo worms (about 0·3 mm. long), which enter the blood-stream. These tiny creatures live in the larger arteries during the day, but towards evening they travel to the capillary blood-vessels under the skin, remaining there until next morning. If a female *Culex* mosquito bites a filaria patient at night, therefore, and sucks blood, it becomes infected with the micro-filaria-worms, which make their way from the mosquito's stomach into the muscles of its fore-body, where they grow to a length of about 1·5 mm. and then enter the mosquito's head, coiling up near the base of its 'beak', ready to enter the skin when the mosquito bites a human victim.

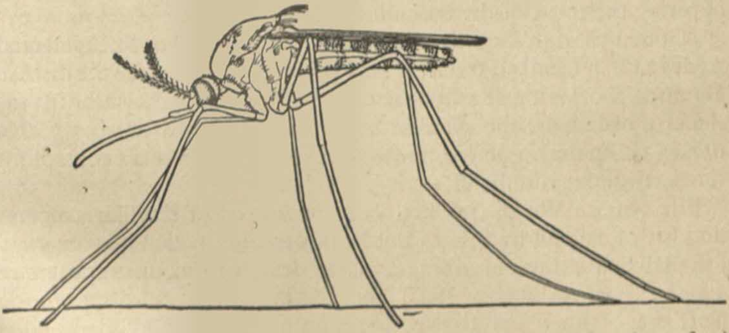


FIG. 23.—*Culex* mosquito (female) resting position (body parallel to the surface) (magnified 10 times)

Aëdes rests in a similar position

Since it is very difficult to get rid of the parasite from an infected human patient by direct treatment, prevention of infection is very important. The chief means of prevention are *mosquito control* and *protection from mosquito-bites* by sleeping under a mosquito-net. It is particularly important that anyone infected with filaria-worms should sleep under a mosquito net.

Another filaria-worm, *Loa loa*, is common in West and Central Africa, and is carried by mangrove* flies. *Loa loa* causes 'Calabar swellings' under the skin. These do not last long and are relatively harmless, but the worm sometimes causes more serious trouble by making its way into the *conjunctiva* (the thin outer membrane* covering the front of the eyeball and inner eyelid).

Another filaria-worm, *Onchocerca*, is found in Man in Equatorial Africa and in Central America, being carried by biting flies. Like *Loa loa*, these worms cause swellings under the skin and may also invade the eye, disturbing the eyesight and sometimes even causing *filarial blindness*. As with *Loa loa*, protection from infection by controlling the carrier-flies is difficult.

The Guinea Worm (see Fig. 7) is the largest of the filaria-worms and is not carried by insects but by water-fleas, which may be swallowed when drinking unboiled water drawn from an unprotected well.

DENGUE AND SAND-FLY FEVERS

The tiger mosquito can also carry the virus of another fever—*dengue*. *Sand-fly fever*—another disease, carried by *sand-flies* and not mosquitoes—is so similar to dengue that it is often impossible to distinguish between the two; but this does not matter much, as the treatment is the same for both. Although neither of these fevers is very dangerous, and patients seldom die, the early stages are like those of yellow fever. If a tiger mosquito bites a dengue patient during the first three days of his fever, it sucks up some of the virus along with the blood. The mosquito becomes infective about ten days later, and remains infective for the rest of its life. If the infected mosquito bites a healthy person, the virus is introduced into his blood. Four to nine days later, he may suddenly have an attack of fever with severe pains in the back and limbs. (Hence dengue is sometimes called 'break-bone fever'.) The fever lasts for three or four days and then disappears for a day or two. Then there is a short return of fever, and measles-like spots appear on the skin. Dengue has to run its course; the patient should go to bed as soon as he feels ill, and stay there for seven to ten days until he feels quite well again.

The best way to control dengue is by the destruction of tiger mosquitoes and the use of mosquito-nets by everybody. Any district with a lot of tiger mosquitoes may have frequent epidemics* of dengue.

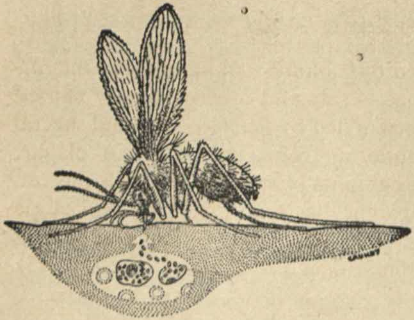
Sand-flies are small enough to pass through an ordinary mosquito-net, hence in places where sand-fly fever and other diseases carried by sand-flies are common (see below), it may be necessary to use bed-nets of finer mesh.* But sand-fly nets restrict air-movement so much that it is uncomfortably hot inside such a net. Sand-flies, however, usually remain near the ground, so they are less troublesome in upstairs bedrooms, especially where there is free air-movement to blow these tiny flies away from sleeping people. Spraying the ground around houses with DDT helps to reduce the number of sand-flies.

KALA AZAR

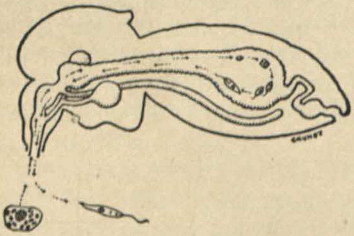
Sand-flies may also carry microscopic one-celled organisms of three species of *Leishmania* that cause *kala azar*, *oriental sore*, and *espundia*, three closely-related diseases (see Fig. 24). *Kala azar*, found in Africa, China, India, and South America, is a slow, wasting disease accompanied by fever. It is nearly always fatal if not treated by injecting suitable drugs. In a malarious country only a doctor can decide whether the patient has malaria or kala azar.

Oriental sore, found in Africa, India, and the Middle East, is a skin sore that develops slowly on exposed parts of the body, usually on the face, arms, and legs. Oriental sore usually cures itself, after many months, and the patient is then immune to further attacks, but the sore can be cured more quickly by injections of drugs.

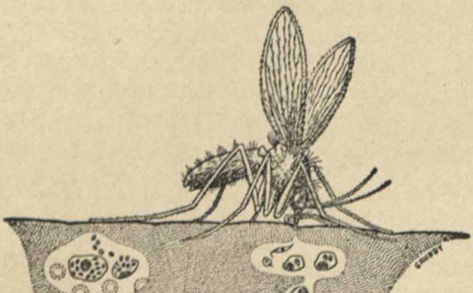
In cases of *espundia* (found chiefly in South America, but also in the Sudan) the sores attack the nose and mouth, destroying large amounts of tissue, and the disease, if left untreated, is often fatal. Treatment is by injecting drugs similar to those used for kala azar, but espundia is a difficult disease to cure.



The sand-fly takes up the leishmaniae (round forms), when it bites a patient (or dog) suffering from leishmaniasis



The leishmaniae develop and increase in numbers by a process of division in the stomach of the sand-fly. They become elongated and move forward to the pharynx, and there multiply so greatly that they block the passage

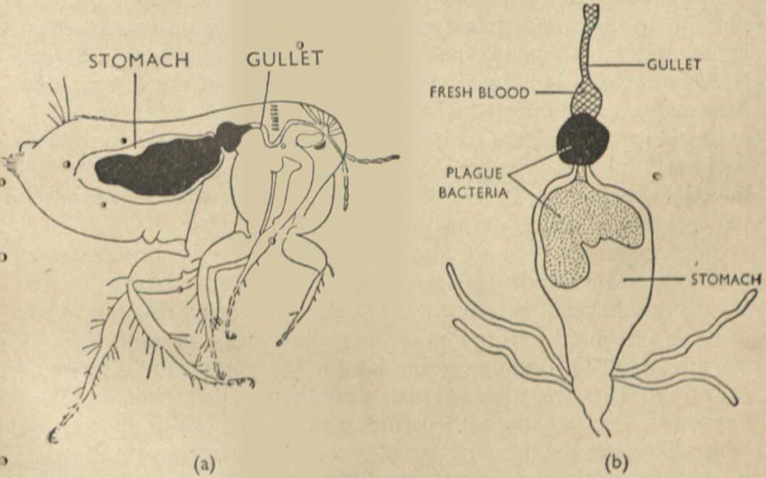


The sand-fly injects the elongated, free-swimming forms into Man (or dogs) when it subsequently attempts to feed. The whole cycle in the sand-fly occupies about 10 days

FIG. 24.—The leishmaniasis cycle

Diagrammatic. The sizes of the parasites and sand-flies are not in proportion to each other

Plague is another disease carried by a blood-sucking insect—the *rat-flea*. Plague is primarily a disease of rats and other rodents,* caused by *plague bacteria*, but it may be carried by fleas to Man and several other mammals. When a rat is suffering from a severe form of plague, the germs of the disease are present in its blood. If a flea bites this rat, it sucks up blood containing plague bacteria. The plague bacteria then multiply so rapidly in the insect's food-canal that a semi-solid mass is formed, blocking up the stomach and gullet (see Fig. 25).



(a) (b)

FIG. 25

(*a*) Rat-flea with 'stomach' blocked with mass of clotted blood and plague bacteria
(*b*) Rat-flea's 'stomach' and gullet blocked with clotted blood and plague bacteria

When the rat dies (usually a few days after being infected) the infected flea leaves the dead body as it cools, and looks for another victim, preferably another rat; but if the flea fails to find another rat it may bite a human being and attempt to suck blood. But as its 'stomach' and gullet are blocked, instead of sucking blood it forces out some of the contents of its gullet into the bite, thus introducing plague bacteria into the victim's tissues. The bacteria multiply and spread through the neighbouring lymph-vessels and may also enter the blood, and, about three days after infection, the outward signs of the disease appear.

About three days after infection there are a sudden rise of temperature, severe headache, and pains in the back. The nervous system is disturbed, and the patient seems to be intoxicated.* About the same time, in most cases, the lymph-glands at the top of the thigh or under the armpit become swollen and tender. The swelling is called a *bubo*, and this type of plague is called *bubonic plague* (or *lymph-gland plague*). Most victims of plague soon die unless treated with recently-discovered drugs.

In some rare cases, buboes do not develop and the plague bacteria multiply in the blood-stream rather than in the lymph-vessels, causing an even more deadly type of plague (*septicaemic plague* or *plague blood-poisoning*). It is from victims in this stage of the disease that fleas may become infected when they suck blood.

In still rarer cases, the patient's lungs become infected with plague bacteria, and this type of plague (*pneumonic plague*) is extremely infectious, being spread by droplet infection. It is so deadly that the patients nearly always die within a few days.

Since treatment does not always cure plague, prevention becomes most important. Rodent-plague always exists before human plague breaks out, hence it is important to destroy as many rats (and their fleas) as possible by trapping, gassing, and poisoning (and fleas by the use of DDT). Buildings, especially in sea-ports, should be made rat-proof. Whenever unusually large numbers of dead rats are found anywhere, a report should be made to the public health authorities, who will collect the rats (with great care) and have them examined in a laboratory. Rats must be stopped from coming ashore from ships in port, and there must be strict quarantine of trains, ships, aeroplanes, and their passengers arriving from plague-infected countries. Anti-plague inoculation gives considerable protection from infection.

TYPHUS

There are several kinds of fever caused by *rickettsiae* (micro-organisms smaller than bacteria but larger than viruses), all of which are carried by blood-sucking insects, mites, or ticks. The four chief diseases in this group are (i) *mite-borne typhus*, (ii) *tick-borne typhus*, (iii) *flea-borne typhus*, (iv) *louse-borne typhus*.

Mite-borne typhus, also known as *scrub-typhus*, *Japanese river fever*, and *tsutsugamushi disease*, is believed to have spread from the banks of certain rivers in the main island of Japan through many parts of the Far East, e.g. Burma, Malaya, and New Guinea. It is a disease of rats and field-mice, carried to Man by the bite of the larva of a tiny *mite* (see Fig. 26). The germs of the disease are present in infected field-mice or rats, and the larval mite (about 1 mm. long) becomes infected when it bites infected mice or rats. The rickettsiae are passed on to the offspring of this mite and these larvae (about 0·2 mm. long) can infect human beings. Men walking through grass where infected rats and mice exist may be bitten by the infected larva of this second generation.* Scrub-typhus is commonest in rat-infested* land that once was cultivated but which has become overgrown with scrub.* The first signs of the disease appear from five to fourteen days after infection, when the fever begins, bringing dangerously high temperatures after a few days and often continuing for two or three weeks if the patient does not die earlier.

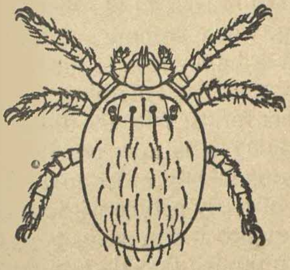


FIG. 26.—Larval mite of the kind which carries scrub typhus (magnified 60 times)

Until very recently no drug was known to cure this deadly disease, but newly discovered drugs are giving very successful results, and, where the new treatment is available, scrub-typhus is no longer such a highly dangerous disease.

To avoid infection, all parts of the body should be covered when walking through infected areas, and a bath should be taken as soon as possible afterwards. An additional precaution is to treat the clothing with certain chemicals which repel or kill the mite larvae. If the tiny, reddish larval mite is discovered on the skin, it should be removed at once and the bite disinfected.

Tick-borne typhus is a disease of rats, mice, and dogs and is found in South, West, and North Africa, southern Europe, North and South America. It is carried by ticks parasitic on these animals and if one of these infected ticks bites a man, he becomes infected. The course of the disease is very similar to that of mite-borne typhus and the new drugs give equally encouraging results.

Flea-borne typhus is a disease of rats, carried from rat to rat by rat-fleas. Infected fleas sometimes bite Man if they cannot find a rat. This is a less common disease than the other forms of typhus and seldom produces an epidemic among human beings.

Louse-borne typhus is carried from man to man by body-lice and is therefore commonest in lousy and crowded communities, especially under cold conditions, where bathing and the changing and washing of clothes are difficult or impossible. In the tropics, where it is usually easy to bathe and to wash one's clothing, louse-borne typhus is less common than the other forms. With the discovery of new and powerful insecticides like DDT it is now possible to kill body-lice very easily, simply by blowing DDT powder up the sleeves and trouser-legs and down the collar of lousy people without even undressing them. This kills all their body-lice and prevents them becoming lousy again for several weeks even though they do not change their clothes. This method has been used with great success among refugees* in time of war or famine* and under cold conditions. Although DDT kills lice, it does not kill the *rickettsiae* in the dried louse faeces, hence clothing from a louse-borne typhus patient must be removed with great care (by someone wearing a pad over mouth and nose) and then boiled or, better, burned, because the disease can be caught by breathing dried infected louse faeces.

LEPTOSPIROSIS

Although this disease is not carried by insects, it is convenient to discuss it here since it is also a disease of rats. The disease is caused by invasion of the blood-stream by a microscopic, one-celled organism called *Leptospira* (hence the disease is sometimes called *leptospirosis*). The germ may enter the body if water containing the urine or faeces of infected rats is swallowed. Infection may also enter through the skin by contact with damp soil in places where there are rats. Swimming in infected pools and rivers is a common cause of infection, since if the germs are in the water they may either be swallowed or enter the body through the skin. Besides this, the damp earth on the bank may be infected, and germs may enter through the bare feet, especially if the skin is broken.

From five to twelve days after infection, there is sudden fever with shivering,* headache, vomiting, and frequent watery motions.

The eyes become bloodshot, and after two or three days the skin becomes yellow and the urine strongly coloured. The disease is often fatal, and a doctor should be called in during the early stages.

To avoid infection, one must be very careful about swimming in pools and streams. Public baths, too, should be rat-proof and the water should be properly filtered and disinfected. Food should be carefully protected from contact with rats. Destruction of rats helps to control the disease.

BILHARZIA DISEASE

The *Schistosomes* (or *Bilharzia*) are parasitic worms causing human disease. They are not transmitted by blood-sucking insects but are considered here because they invade the blood-stream. In some parts of Africa, no less than 50 per cent. of the population are infected with these schistosomes. The parasite is a small worm, or *fluke*, which lives in the veins, mainly in the portal vein near the bladder and rectum. The male fluke is shaped like a leaf, about half an inch in length, and

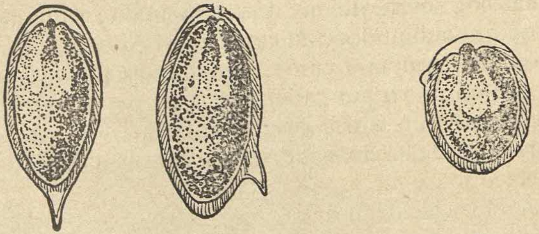

(a) (b

FIG. 27.—Eggs of schistosomes (magnified 200 times)

a. Schistosoma haematobium. Schistosoma mansoni. b. Schistosoma japonicum rolls up to form a channel in which the female fluke lives, laying her eggs in the victim's portal vein. These eggs are oval in shape, bearing a sharp point, and they bore their way through the walls of the bladder and rectum, causing irritation and bleeding (see Fig. 27). The eggs burst as soon as they reach water, setting free tiny embryos which swim about searching for their intermediate host, a fresh-water snail (see Fig. 28). If an embryo finds a snail, it bores its way into the snail's 'liver' where it undergoes a series of changes, finally producing a number of microscopic, tadpole*-shaped animals which escape into the surrounding water, where they swim about looking for their other host—Man. If they do not find a human host within thirty-six hours after leaving the snail, they die. If they find a man, they bore through his skin, causing severe itching, make their way to the portal vein, and develop into adult blood-flukes after a few weeks, thus completing the life-cycle. A doctor can cure bilharziasis by injecting a drug. Infection can be prevented by (*a*) not walking or bathing in water containing snails (or which has contained snails during the last thirty-six hours), and (*b*) by not drinking unboiled water from natural sources.

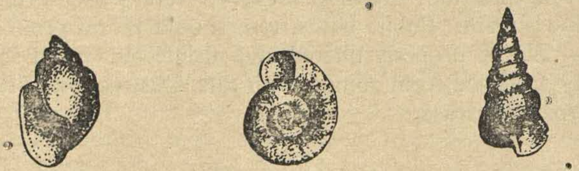


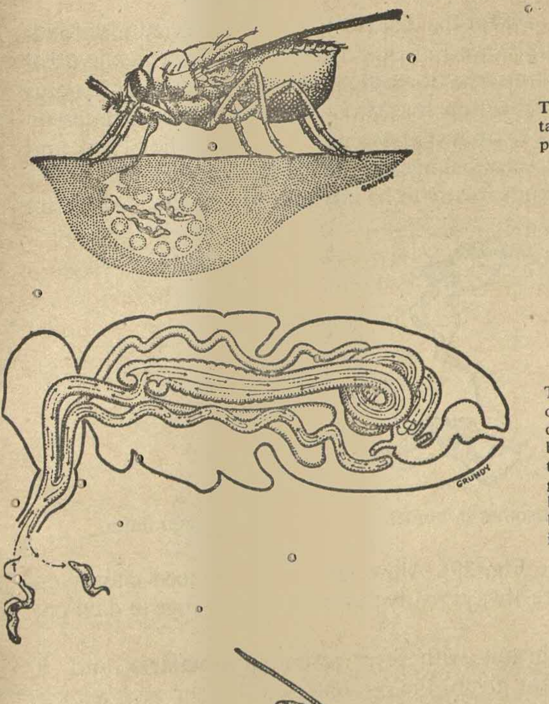
FIG. 28.—Snail hosts of schistosomes, slightly enlarged

a. Bulinus Schistosoma haematobium) · *b. Planorbis* (*Schistosoma mansoni*) · *c. Oncomelania* (*Schistosoma japonicum*)

The snails in which the flukes pass part of their life-cycle prefer slow-moving or still water, e.g. irrigation* canals, ponds, and lakes, and the use of untreated water from such sources for bathing or drinking must be avoided.

SLEEPING SICKNESS—TRYPANOSOMIASIS

Sleeping sickness is an insect-borne disease occurring in tropical parts of Africa. It is caused by a one-celled animal (called a *trypanosome*—



The tsetse fly (male or female) takes up the blood of the sick person, which contains trypanosomes

The trypanosomes enter the gut of the tsetse fly, and there they develop and increase in numbers by a process of division. The trypanosomes travel along the gut to the end of a lining membrane, and then they double back between it and the gut wall, passing into the proboscis and from there into the salivary glands

From the salivary glands the trypanosomes are injected into animals (or Man) at subsequent feeds. The whole cycle in the tsetse fly occupies about 20 days

FIG. 29.—The trypanosomiasis cycle

Diagrammatic. The sizes of the parasites and tsetse flies are not in proportion to each other hence the scientific name for the disease[1]), living in the victim's bloodstream or lymph-vessels (see Fig. 30). These blood parasites live not only in Man but also in some domestic and wild animals, which thus provide a source of infection for Man. When a *tsetse fly* bites an infected person, it sucks up trypanosomes along with the blood, and after undergoing a series of changes in the insect's gut they make their way to its salivary glands, ready to be introduced into the next victim when the fly bites (see Fig. 29). Although tsetse flies feed mainly on other animals, they are always ready to bite human beings in daylight out-of-doors.

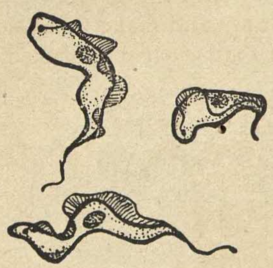


FIG. 30.—Trypanosomes in human blood (magnified 1,000 times)

Sleeping sickness begins with fever resembling malaria, and, if proper treatment is not given, the patient gets thinner and weaker until he dies of the disease. *Early* treatment with modern drugs, however, gives very successful results: another example of the importance of getting proper medical attention as soon as anyone is attacked by fever.

RELAPSING FEVERS

Relapsing* fever is caused by the presence in the blood of tiny one-celled parasites called *spirochaetes* (from their spiral shape, see Fig. 31). These spirochaetes are carried either by lice or by soft ticks. About a week after infection, the patient suddenly develops fever resembling malaria or sleeping sickness. Then, after a few days, his temperature goes down to normal and he thinks his illness is over until, a few days later, he has a *relapse* and the fever returns. Relapsing fever is a dangerous disease, hence it is important to have the blood examined under a microscope whenever anyone begins to get fever. Relapsing fever, in particular, must receive skilled medical treatment.

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[1] *N.B.* Sleeping sickness (trypanosomiasis) must not be confused with 'sleepy sickness' (encephalitis), which is a virus disease whose transmission is not yet fully understood.

Tick-borne relapsing fever is carried by soft ticks that take in spirochaetes when they suck blood from an infected person. Then the spirochaetes multiply and make their way to the tick's salivary and other glands, so that when the infected tick next sucks blood, some spirochaetes enter the victim's body. In countries where tick-fever is common, it is important that the walls and floors of houses shall be free from cracks in which ticks may hide. Where such cracks occur, a suitable insecticide like BHC (benzene hexachloride) should be used to kill the ticks.

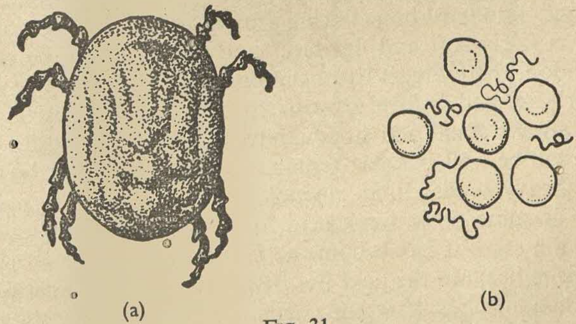

(a) (b)

FIG. 31

a. Soft tick (*Ornithodorus*) (magnified 4 times)
Carrier of one form of relapsing fever
b. Spirochaetes of relapsing fever in human blood, with red blood-cells (magnified 1,000 times)

Louse-borne relapsing fever is transmitted by lice which have fed on infected blood. After multiplying inside the insect, the spirochaetes cannot escape unless the louse is crushed (e.g. by scratching). In this way the spirochaetes are set free on the victim's skin and may find their way into his blood. The prevention of louse-borne relapsing fever depends on the destruction of lice and this has been discussed on p. 92 when dealing with louse-borne typhus.

CHAPTER

HYGIENE OF THE SKELETAL, MUSCULAR, AND NERVOUS SYSTEMS

The skeleton forms the framework of the body and gives it its definite shape, besides protecting the more delicate organs. At about twenty-five years of age, the bones stop growing and their shape is fixed.

A baby's skeleton consists largely of soft cartilage, which gradually changes into hard bone during growth. For this reason, a child's skeleton is fairly soft and flexible,* and its shape can be changed. In childhood, therefore, it is very important to see that the skeleton is properly shaped before growth stops and the bones harden. If children always stand and sit squarely, in an upright position, their skeleton will be well shaped. Young children should not be allowed to carry heavy loads. If an uncooked chicken bone is soaked in vinegar* or some other weak acid for a few days, although it will still *look* the same it has become so flexible that it can be tied in a knot. This is because the acid has dissolved out the mineral matter (mainly calcium phosphate and carbonate) leaving only the organic framework. If a similar bone is burnt, however, it becomes brittle* because the organic material has burned away. The bones of young children are richer in organic matter and therefore much less brittle than those of old people (whose bones contain more mineral matter). Children's bones, therefore, break less readily than those of adults, and their fractures* mend more easily. In fact, when the bones of children do break, they usually remain connected at one side of the fracture, just as a green stick does not break clean across (as does a dead dry stick). Hence the term 'green-stick' fracture is applied to such cases.

Good posture during childhood helps to provide an efficient, well-shaped skeleton in the adult. Besides this, a properly developed skeleton allows plenty of room for the free action of the heart, lungs, and other organs of the body. Physical exercises and suitable games provide the best means for proper development of the skeleton and also for correcting such defects* as stooping,* round shoulders, or holding one shoulder higher than the other (see Figs. 32 and 33).

Since the hard, mineral part of bone is mainly calcium phosphate, it is essential that the diet of a growing child should contain sufficient *calcium* and *phosphorus* compounds in the right proportions. But in order to absorb these calcium and phosphorus compounds, the body must have sufficient *vitamin D*. Vitamin D, we have seen, is present along with vitamin A in milk, butter and eggs, and in fresh, green, leafy vegetables. It is also formed from *ergosterol* in the skin when exposed to sunlight (hence there need be no lack of vitamin D in tropical countries), and any child eating sufficient of these foods and getting sufficient sunlight and out-of-doors exercise, together with proper rest and sleep, is supplying the needs of the young skeleton. In some cases it may be desirable to increase the intake of vitamin D by giving the child fish-liver oil.

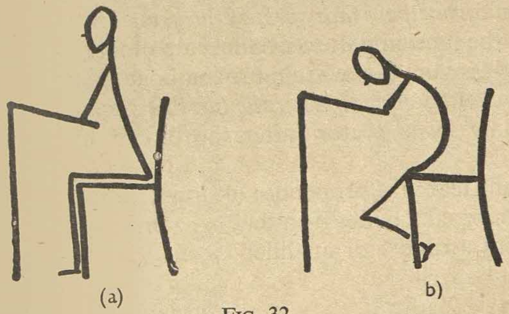

(a) b)

FIG. 32

(*a*) Good writing position (*b*) Bad writing position

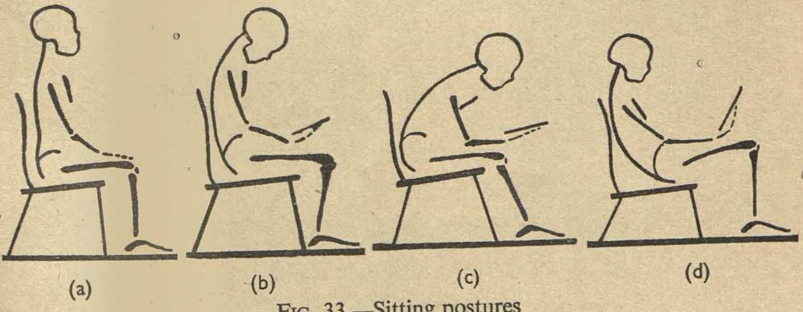

(a) (b) (c) (d)

FIG. 33.—Sitting postures

(*a*) Good (*b*) (*c*) (*d*) Bad

BONE INJURIES—FRACTURES

Everyone should know a few guiding principles about how to deal with broken bones. The chief principle is, 'Do not make things worse by moving the injured person unnecessarily.' If possible, let him remain where he is until the doctor or the ambulance* comes. If the injured person *must* be moved before proper medical attention arrives, *the injured part must first be protected from further injury* by bandaging the injured part to a splint* or similar firm support. With a *compound fracture* (i.e. when a broken bone is sticking out through the skin) *do not try to push back the bone beneath the flesh.* This must be done only by a doctor (after thoroughly cleansing bone and wound).

You should learn the proper use of slings,* bandages, and splints in dealing with broken bones by attending a *practical** First Aid course conducted by a doctor or qualified expert.

TEETH

An important characteristic of mammals is their more or less permanent specialized teeth. The teeth of all mammals are built on the same ground-plan, although they may differ widely in size and shape according to the animal's feeding habits, e.g. the *carnivores* (or flesh-eating mammals, such as the dog, cat, lion, tiger) have teeth adapted mainly for tearing and cutting, while the teeth of *herbivores* (or plant-eating mammals like sheep and cattle) are adapted chiefly for chewing and grinding.

In every type of tooth, the part which is seen projecting into the mouth is called the *crown* of the tooth, while the part embedded in the jaw-bone is called the *root* (see Fig. 34). The region level with the *gum*, where the crown joins the root, is called the *neck* of the tooth. The greater part of a tooth consists of *dentine* (or ivory). Dentine, although very strong, is somewhat elastic, so that it supports sudden pressure without breaking. Dentine, however, is too soft to stand continuous wear, and the crown of the tooth is covered with a thin layer of a very hard substance called the *enamel.* Enamel is the hardest tissue in the body, and in fully-grown teeth it consists almost entirely of mineral (inorganic) material. Although the enamel is brittle, it is saved from breakage because it rests on the elastic dentine beneath. The enamel extends to the neck of the tooth. The dentine of the root is covered with a thin layer of bone-like *cement*, which helps to fix the tooth in its socket* in the jaw. In the middle of the dentine is the *pulp-cavity*, containing a soft mass of blood-vessels and nerves, which enter through a tiny hole at the tip of the root (see Fig. 34).

Mammals have different kinds of teeth, each useful for different work. In Man, there are four kinds of teeth: (*a*) *Incisor teeth*—flattened, cutting teeth for biting and tearing food. These are the four front teeth in each jaw. (*b*) *Canine teeth*—more pointed and stronger than the incisors: two in each jaw, on either side of the incisors. These canine teeth are best developed in flesh-eating mammals, e.g. cats, dogs, and tigers, and are used for seizing their living victims. (*c*) *Pre-molar teeth*—four small teeth in each jaw for breaking and crushing the food, placed in pairs behind each canine

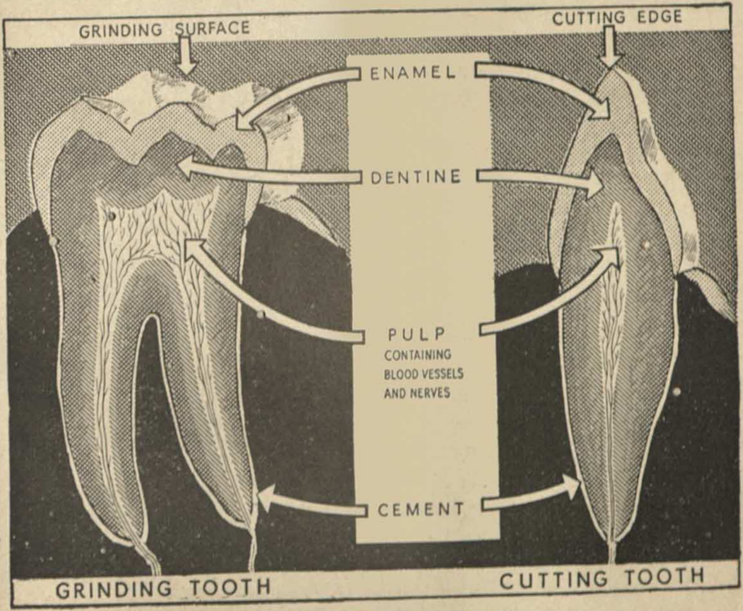


FIG. 34.—Tooth structure

tooth. (*d*) *Molar teeth*—twelve large, 'double' teeth for grinding up the food and mixing it with saliva: three on either side of each jaw. There are no true molars in the temporary 'milk-teeth'; the so-called 'milk-molars' are pre-molars (see Fig. 35).

Man grows two sets of teeth—a *temporary* set* during childhood and a *permanent* set* when grown up. When a baby is about seven

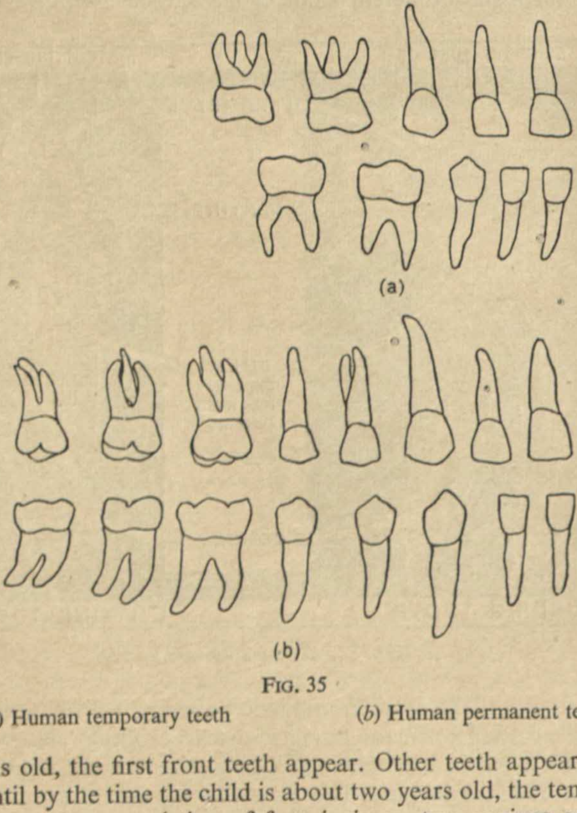


FIG. 35

(*a*) Human temporary teeth (*b*) Human permanent teeth

months old, the first front teeth appear. Other teeth appear gradually until by the time the child is about two years old, the temporary set is complete, consisting of four incisors, two canines and four pre-molars in each jaw. These twenty 'milk-teeth' serve the child until it is about six years old. During this time the jaws are growing longer, thus making room for the *permanent teeth*, which are gradually developing inside the jaws (see Fig. 36). At about six years of age, the first permanent molars appear, behind the temporary molars, and during the next few years the temporary teeth loosen and fall out, being replaced by the permanent teeth, until by the fifteenth year only the third molars (or 'wisdom teeth') have still to appear. The complete set of permanent teeth, therefore, consists of four

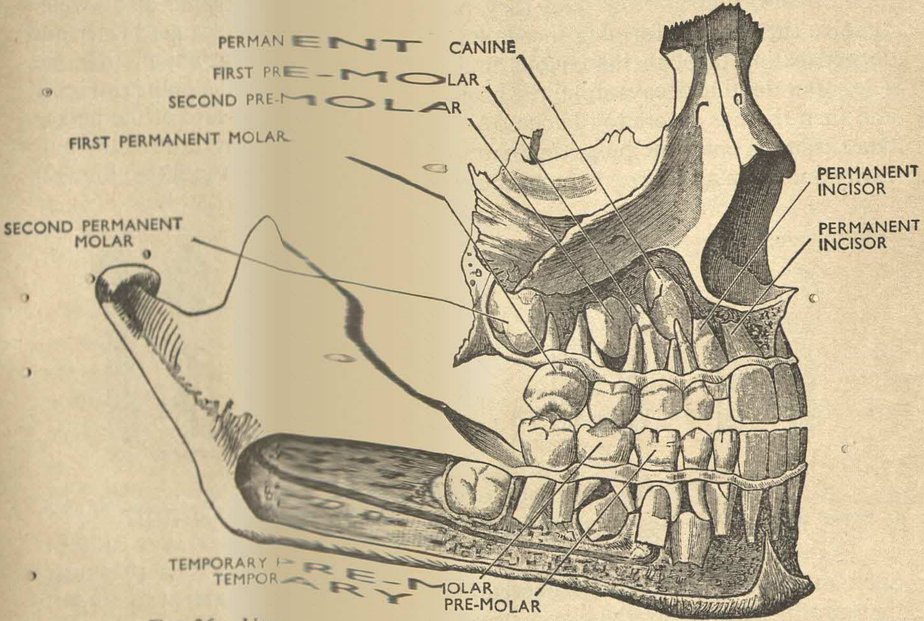


FIG. 36.—Upper and lower jaws of a six-year-old child

All the temporary teeth are present and the first permanent molars are coming through. The permanent teeth can be seen forming behind the temporary teeth

incisors, two canines, four pre-molars, and six molars in each jaw, a total of thirty-two teeth.

This is the most convenient point at which to consider diseases of the teeth and their prevention.

Diseases of the teeth

The causes of dental* disease are best considered under two main headings: (i) *local causes*, which affect the teeth directly, and (ii) *general causes*, which affect the body in general and the teeth in particular.

(i) *Local causes of dental decay*. Actual decay is caused by certain kinds of bacteria. Our mouths, and the food we eat, contain large numbers of bacteria, of many different kinds. Most of these bacteria are harmless, but some of them feed on food particles left sticking to the teeth, and as they feed they produce organic acids which dissolve the enamel, forming tiny holes. These holes get bigger and deeper, eating through the enamel and extending into the dentine. The softer dentine decays still more rapidly, until the pulp is attacked and then there is severe toothache owing to exposure of the nerves. Once bacteria enter the pulp, they can travel down through the pulp cavity and form an *abscess** round the root of the tooth (see Fig. 37).

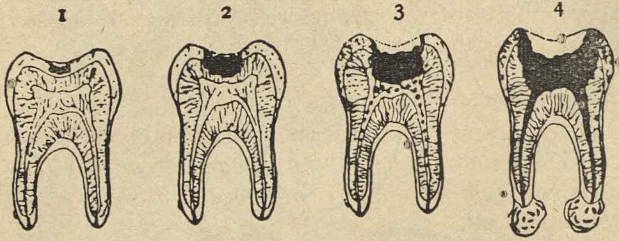


FIG. 37.—Four stages of dental decay

1—Enamel begins to decay. 2—Dentine also begins to decay. (A dentist can save this tooth.) 3—Pulp begins to decay. 4—Pulp completely decayed; abscesses formed

Such an abscess is a mass of bacteria, and the poisonous substances they produce may enter the blood-stream and be carried to all parts of the body, causing other disturbances. An abscess may cause a gumboil or a swelling of the face, which drives the sufferer to a dentist.* Sometimes, however, an abscess causes no local pain since its poisonous products are being carried away to other parts of the body by the blood-stream, causing serious disturbances which seem to have nothing to do with the teeth until an X-ray picture of the jaw shows the real cause.

Another local cause of dental decay is badly-shaped, unevenly-spaced teeth. Such teeth are difficult to keep clean, since it is not easy to remove particles of food from the awkward spaces between the teeth.

(ii) *General causes of dental decay.* If dental decay were due only to such local causes, then clean, well-shaped, and well-spaced teeth should never decay. (In fact, it was formerly believed that 'a clean tooth never decays'.) Unfortunately, such teeth often do decay, hence there must be other causes of decay besides those which affect the mouth and teeth directly.

Many teeth which appear quite normal on the surface are badly formed inside, and such teeth very often decay. In some cases, a serious illness or a long period of ill-health during childhood results in a small area of badly-formed enamel which is easily dissolved by acids.

Proper diet has a great influence on the formation of good teeth, and we have seen (on p. 20) that although a diet may contain enough calcium and phosphorus compounds, the body cannot make use of these compounds to grow strong, well-formed teeth unless *vitamin D* is also present in the diet.

Prevention of dental disease

In order to prevent dental disease, four main conditions are necessary: (i) *The teeth must be well formed and strong.* (ii) *They must be well arranged in the mouth.* (iii) *They must be properly used.* (iv) *They must be kept clean.*

(i) We have seen that in the formation of good, strong teeth it is necessary to have a suitable diet containing enough *calcium* and *phosphorus* compounds, together with *vitamin D.* Such a diet will include milk, eggs, butter, cheese, animal fat, fresh fruit and green vegetables.

(ii) If the teeth are regular in shape and well spaced in the mouth, they are less likely to decay and will chew the food better. Young children should not be given 'comforters' to suck, and should not be allowed to suck their fingers, as these practices often displace the growing teeth. In some children, the temporary teeth remain too long in the jaw and hinder the normal growth of the permanent teeth. In such cases, the temporary tooth which is in the way should be pulled out to allow the permanent tooth to move into its proper position (see Fig. 36).

(iii) One of the main causes of the dental decay so widespread in 'civilized' communities is the *lack of tough food requiring vigorous chewing.* The teeth and jaws are adapted for biting, crushing, and grinding food. 'Uncivilized' peoples, eating coarse, tough, uncooked food, often avoid the dental decay which is so common among 'civilized' peoples. If the jaws are not properly used in childhood they remain small and narrow so that there is not enough room for the teeth. Active use of the jaws during chewing stimulates the blood-supply to the teeth and the flow and movement of saliva. Apart from its digestive action, saliva cleans the teeth by washing away food particles. The alkaline saliva also neutralizes the harmful acids formed by the bacteria which cause decay. Hard chewing of tough, fibrous foodstuffs also helps to clean the teeth by removing the sticky film left by soft starchy and sugary foods.

Unfortunately, under modern conditions, with diets of soft, over-refined, cooked food, very little chewing is required. Hence the diet must always include hard and fibrous food materials to encourage the healthy habit of chewing. Substances like *hard* biscuits, bread-crusts, fresh fruits, and raw green vegetables are all of value from this point of view. Chewing sugar-cane is particularly good for the teeth.

(iv) We have seen that with a proper diet and vigorous chewing, no artificial cleansing of the teeth would be necessary, but under conditions of 'civilized' life, artificial methods have to be used. A tooth-brush or fibrous stick is generally used for the purpose, brushing *all* the surfaces of *all* the teeth with up-and-down and round-about movements rather than backwards and forwards in a horizontal direction. As far as possible brushing should be *from* the gums so as to keep the gum pressed tightly around the neck of each tooth. A tooth-paste or powder helps the cleansing effect. In place of expensive commercial tooth-pastes and powders, a strong solution of common salt, or of baking soda (sodium *bi*-carbonate), or a mixture of the two, will help the tooth-brush to do its work. The teeth should always be cleaned before retiring for the night, after taking the last food for the day, so that the harmful bacteria may not become active during the hours of sleep. If possible, the teeth should be cleaned after each meal; the mouth, at least, should be thoroughly rinsed out with clean water.

Tartar is the name given to a hard deposit that often forms on teeth (particularly behind the lower incisors in adults). It consists of a mixture of calcium phosphate and calcium carbonate bound together by organic matter. Tartar should be removed periodically (by a dentist) because it may force back the gum and expose the dentine around the neck of a tooth below the enamel.

Dental inspection

Nearly all the permanent teeth develop during school-days, and the main object of school dental inspection is to ensure that there shall be a set of strong, healthy teeth in the adult. Regular inspection by a qualified dentist makes it possible to discover the early stages of decay and then save valuable teeth by discovering and filling tiny cavities. Dental decay is commonest during early life and the process is more rapid in the young than in adults.

VALUE OF MUSCULAR EXERCISE

It is by means of the muscles that the various parts of the body move. If the muscles are to do this efficiently they must be strong and healthy. To build up the muscles of a growing child, a sufficient supply of suitable food is required. After absorption, the food material must be carried to the muscles by the blood. *Exercise* increases the flow of blood to the muscles. Without exercise the muscles do not develop properly, but remain soft and weak. People that do heavy muscular work for several hours every day, using the large muscles of the body, get all the muscular exercise they require; but people doing indoor work, often sitting down for hours at a time, are not using their muscles sufficiently. It is most important that every normal person should exercise the muscles actively, so as to produce (*a*) *free sweating*, (*b*) *full action of the lungs*, (*c*) *increased action of the heart*, and (*d*) *more rapid circulation of the blood.*

Exercise not only makes the muscles strong and healthy, it also does good to every organ of the body. We may summarize the effect on the various body-systems as follows: (i) *The blood system*—Exercise makes the heart beat quicker and makes the circulation more rapid, resulting in a better blood-supply to the tissues, carrying food material and oxygen and removing waste material. (ii) *The skin*—Exercise causes the sweat-glands to become very active, giving out water and waste substances from the skin. (iii) *The lungs*—During exercise, the lungs become more active, breathing is deeper and the air in the lungs is changed more often, so that more oxygen is taken in and more carbon dioxide and water-vapour given out. (iv) *The* *food-canal*—Exercise encourages regular action of the intestines and prevents constipation. (v) *The nervous system*—Exercise stimulates the nervous system, refreshing the brain owing to the increased circulation of the blood.

Outdoor games of skill, e.g. cricket, football, hockey, tennis, &c., provide exercise for both the muscles and the brain, since it is only when the nervous system is working perfectly that the muscles can be properly controlled. Active muscular exercise is particularly important for those who spend several hours a day in 'brain work'. Merely watching games is useless. The healthy youngster who gets plenty of suitable food and exercise will usually develop a good posture.

FATIGUE—REST—SLEEP

Too much exercise causes *fatigue*,* both muscular and nervous. We feel tired not because the carbohydrate in the muscles has been oxidized and used up, but because the chemical products of the oxidation are not being removed fast enough by the blood. Fatigue, therefore, is not like the loss of power of a petrol-engine through a stoppage in the fuel supply, but rather like the loss of power in a machine whose moving parts are stiff with dirt. The cure for fatigue is *rest*.

During rest, the harmful products of the activity of muscle- and nerve-cells are removed by the blood while the tissues are repaired and made ready for further activity. Whenever possible, it is better to *lie down* to rest, so as to relieve the heart of the work done in pumping blood against gravity.* The best form of rest is *sound sleep*. During sleep we become unconscious of outside happenings, and body and brain get a complete rest. The muscles relax, the heart beats more slowly, and the breathing becomes shallow. Most people in the tropics need eight hours of unbroken sleep every night. *Growing children should never have less than this.*

HYGIENE OF THE NERVOUS SYSTEM

The nervous system is so closely connected with the muscular system that what has been said about the hygiene of the muscular system applies also to the nervous system. *Fatigue* affects the nerves even more than the muscles. The most tiring work never completely fatigues the muscles. Long before this stage is reached the nervous system has become so fatigued that it cannot supply the necessary impulses* to keep the muscles moving. *Rest* and *sleep*, therefore, have even more important effects on the nervous system than on the muscles.

The brain, too, needs 'exercise'. A man who does the same work every day in the same way needs a change during his spare time. This is one of the main reasons for the value of a spare-time *hobby** which exercises the brain in a different way. Hence the 'brain-worker' should have a hobby which needs some muscular effort, while the hand-worker should have a hobby which needs some effort of the brain.

HYGIENE OF THE SENSE-ORGANS

There are five main ways in which we get information about the outside world—by our senses of *sight*, *hearing*, *taste*, *smell*, and *feeling* (touch, temperature, and pain); and it is important to keep all the *sense-organs* working efficiently if we are to respond properly to outside stimuli.*

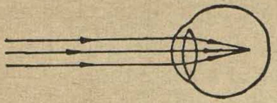
Hygiene of the eyes

The eye is Man's most important sense-organ, and poor eye-sight is a great handicap. Common defects are *short-sight* (or near-sightedness) and *long-sight* (or far-sightedness). A near-sighted (or short-sighted) person can only see objects clearly when they are near to him, and he cannot see clearly objects beyond a certain distance. This is because the transparent covering in front of the eyeball is too much curved or because the eyeball is too long from front to back, so that parallel rays from a distant object are brought to a focus* *in front of the retina.* In other words, the converging* effect is too great, as shown in Fig. 38(*a*). This can be corrected by placing a suitable concave* (or diverging*) lens in front of the eye, so that the image* of a distant object is formed on the retina (Fig. 38(*b*)). *A short-sighted person, therefore, needs eye-glasses* (or *spectacles*) *with concave lenses.* A near-sighted child can read easily and often does well in class, but out of class he cannot see clearly enough to play games well. So he tries to avoid games and becomes a 'book-worm'.* By wearing suitable spectacles, the handicap of short-sight can be overcome.

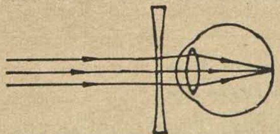
A *long-sighted* person can see distant objects clearly but not near objects. This is because the transparent covering in front of the eyeball is not sufficiently curved or because the eyeball is too short from front to back, so that rays from a near object are brought to a focus *behind the retina.* In other words, the rays are not converged sufficiently, as shown in Fig. 38(*c*).

This fault can be corrected by placing a suitable *convex** (or converging) lens in front of the eye so that the image of a near object is formed on the retina (see Fig. 38(*d*)). *A long-sighted person, therefore, needs eye-glasses with convex lenses.*

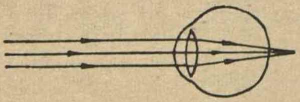
A third kind of eye-trouble often develops as people get older, when the eye-lens gets harder and less elastic, and the ring of muscle is unable to squeeze it sufficiently to make it more convex when looking at near objects. Older people, therefore, often need glasses with *convex* lenses for reading; in fact they often require two pairs of glasses, one for reading and one for viewing distant objects. Such people often find it convenient to have both types of lenses combined in a single pair of *bi-focal spectacles*, with 'distant' lenses above and 'reading' lenses below. This arrangement makes it unnecessary to have two separate pairs of glasses and to change from one pair to the other at frequent intervals.



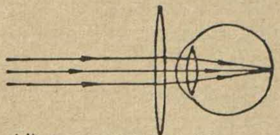
(a) SHORT-SIGHTED EYE



(b) CORRECTION OF SHORT-SIGHT



(c) LONG-SIGHTED EYE



(d) CORRECTION OF LONG-SIGHT

FIG. 38.—Faults of eyesight and their correction

Another very common eye-defect, often overlooked, is *astigmatism.* This is caused by irregular curvature of the eye-lens or of the transparent window in front of the eye, which are often slightly spoon-shaped and not spherical. This defect is easily corrected by wearing suitable glasses. Eye-defects should be treated at as early a stage as possible, or the eyes may be permanently damaged. Early treatment, e.g. the wearing of suitable glasses, will often remedy the defect. Headaches and nervous trouble are often caused by slight defects of eyesight, owing to the continuous unconscious effort to correct the defect. The choice and fitting of suitable glasses, however, call for skilled knowledge, and should be directed by a medical eye-specialist wherever possible. Eye trouble is sometimes only a signal of some other disturbance in another part of the body which will not be cured by wearing glasses. A doctor can find out and treat the *cause* of the trouble. Do not put off wearing glasses if an eye-specialist says you need them. Wearing suitable glasses will help to prevent your eyes getting worse and will also improve your general efficiency. Reading and writing should always be done in a good light, with no shadows on the page and no direct reflection from the shiny paper. In reading and writing, the book or paper should be square to the front and not nearer than twelve inches from the eyes.

Most of the diseases that affect the eyelids and the front of the eyeball are caused by infected dust and dirt entering the eyes. The eyes must never be rubbed with dirty hands or with a dirty towel. At the first sign of any redness or soreness about the eyes, they should be bathed with a weak antiseptic, e.g. a solution of boric acid. If this treatment does not put things right, a doctor should be consulted.

Eye diseases are very common in tropical countries (particularly among people whose diet is lacking in vitamin A). One of the commonest and most serious of these is *trachoma*, which is responsible for many cases of partial or total blindness. It appears to be caused by a virus which is present in the discharge from diseased eyes and is carried from the sick to the healthy by fingers, flies, towels, handkerchiefs, &c. As trachoma is very difficult to cure, prevention is most important, and anyone suffering from sore eyes should be isolated as far as possible, and should not share towels, soap, wash-basins, or any similar articles with other people.

Although the movement of the eyelids usually stops solid particles from entering the eye, it sometimes happens that bits of hard material get under the eyelid and become very painful. If hard particles get in the eye, it is very important not to rub the eye. Get a friend to remove the object on the corner of a clean handkerchief, or do it yourself with the aid of a mirror. If the object is only small, it will usually find its way to the inner corner of the eye where it can be easily removed. If there is the slightest difficulty in removing something from the eye, go to a doctor or a dispensary.

The front of the eyeball is kept always wet with 'tears', and when you get anything in your eye more 'tears' are produced to wash away the obstruction. Tears form one of the strongest natural antiseptics and provide your best means of protection against eye-infections.

Hygiene of the ears

The middle ear and the inner ear are completely enclosed in thick bone and are thus well protected. On the other hand, if anything goes wrong inside the internal ear, treatment is very difficult. The outer ear is merely a tube leading to the ear-drum. Wax is formed on the lining of this tube, and this sticky material traps dust and keeps out insects. The commonest trouble in this part of the ear is the accumulation of too much wax. Some people produce so much wax that it blocks up the tube and makes them deaf. A small excess of

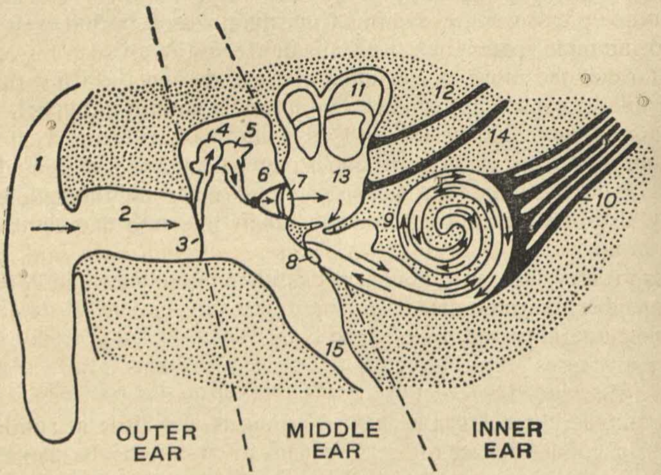


FIG. 39.—Vertical section through right ear (diagrammatic)

1—external ear. 2—tube leading to ear-drum. 3—ear-drum. 4, 5, 6—chain of bones. 7—oval window. 8—round window. 9—organ of hearing. 10—nerves of hearing. 11—semicircular canals. 12—nerve of sense of direction of movement. 13—organ of balance. 14—nerve of sense of balance and position. 15—tube leading to throat wax can usually be removed by twisting up the corner of a soft handkerchief and turning it *gently* round in the ear. No solid article should ever be put into the outer ear. Larger deposits of wax and any foreign bodies should be removed by a doctor, by careful syringing* so as to avoid harming the delicate ear-drum.

As far as possible, water should not be allowed to enter the outer ear, but if it does the tube should be thoroughly dried afterwards. This is particularly important in tropical countries where the spores of fungus* diseases may find their way into the ear along with water. Never dry your ears with a dirty towel.

The middle ear is connected with the throat by a narrow tube (the 'Eustachian tube'), about 1½ inches long, which serves to equalize the pressure in the middle and the outer ear. This tube is sometimes a source of danger, since germs from the throat may find their way into the middle ear. Ear-ache is the danger-signal of such infection, and a doctor should be consulted at once. Any pus which forms in the middle ear cannot drain away naturally, and if the infection is neglected, there may be very serious results. The ear-drum itself may be burst or the chain of small bones may be disturbed, causing deafness. Worse still, the thick but spongy bone enclosing the middle ear may also become infected, and in this way infection may spread to the brain with fatal results. (As a famous surgeon once said, 'It is safer to carry dynamite* in your pocket than pus in your middle ear.') Remember, therefore, that *ear-ache (especially in a child) is a sign of danger*, and consult a doctor at once.

Hygiene of the organs of taste, smell, and touch

The tongue is the organ of taste, and needs very little attention to keep in good working order. The sense of taste may be damaged, however, by eating too highly flavoured food (e.g. 'hot curries') or by excessive smoking.

The upper part of the nose-cavity contains the organ of smell. When this cavity is blocked with sticky fluid (mucus) owing to a 'cold in the nose', the sensitive nerve-endings are covered and the sense of smell is lost. Under such conditions, be careful how you 'blow your nose', pressing one nostril at a time and keeping the lips apart. The common method of first filling the lungs with air, holding both nostrils firmly, closing the mouth tightly and then blowing hard through the nose often forces infected mucus up the Eustachian tubes (see Fig. 39) and also into the bony cavities (*sinuses*) that open out from the nasal cavity.

The organs of feeling in the skin—sensitive to heat, cold, touch, and pain—are kept working efficiently if the skin is kept clean and healthy.

CHAPTER 6

HYGIENE OF THE SKIN

The skin protects the body from cold, wet, hurt, and invasion by bacteria. We have also seen that it plays an important part in regulating the body-temperature and that it plays a small part in getting rid of some waste products from the body. If the skin is to do this work properly, it must be kept *clean*. In hot countries, the skin gives off a lot of water, hence the sweat-pores must be kept clean. As the water in the sweat evaporates, a small quantity of solid matter is left behind. At the same time, the oil-glands in the skin give out an oily substance. Dead skin-cells and dust stick to this greasy layer of dried sweat, and if this dirty mixture is allowed to remain on the skin, it will become both unhealthy (since it harbours disease germs) and unpleasant (since it soon decomposes). The best way of cleansing the skin is with soap and water. Proper rubbing with soap is the only way to clean the skin thoroughly, merely standing beside a well or tap and throwing water over the body is not enough. A warm bath has the best cleansing effect, but tap-water in tropical countries is usually warm enough for the purpose. However, a warm bath (i.e. slightly below body-temperature) makes the sweat-glands in the skin more active, and the blood-vessels widen and thus increase the blood-supply to the skin. If this is followed by a cold shower, the body gets a mild shock, the skin adjusts itself to the sudden change and the blood-vessels in the skin contract.

It is a good practice to give the skin a mild shock in this way, as it gets the skin into the habit of adjusting itself quickly to sudden changes of temperature. If the skin is then dried with plenty of hard rubbing (provided the skin is healthy and free from irritation, e.g. prickly heat), the skin muscles are exercised, the circulation again becomes active, and the whole body feels refreshed and full of vigour.* Particular care should be taken, however, that the skin is dried thoroughly where two skin-surfaces are in close contact, e.g. between the toes, otherwise germs of skin diseases may attack these parts. It is a good plan after bathing to remove most of the water from the skin with a small towel (about 12 in. square), and then dry the skin thoroughly with a larger dry towel. The small towel should then be well washed and hung up to dry ready for the next bath. Besides bathing the whole body at least once a day, we should wash the hands frequently, especially before meals, to avoid infecting the food. Dirty fingernails, too, often carry infection. They should be cut short and kept clean by scrubbing with a small brush.

Under hot and humid conditions, when sweat is produced more rapidly than it can evaporate, the skin may remain wet beneath the clothing, particularly around the waist and under the arm-pits. This sometimes causes *prickly heat* through irritation and inflammation of the skin. To prevent prickly heat the clothes should allow free ventilation. Shorts and a loose-fitting, short-sleeved, open-necked, coat-style shirt (worn outside the shorts—which should not be too tight round the waist) keep the skin well ventilated. In hot countries

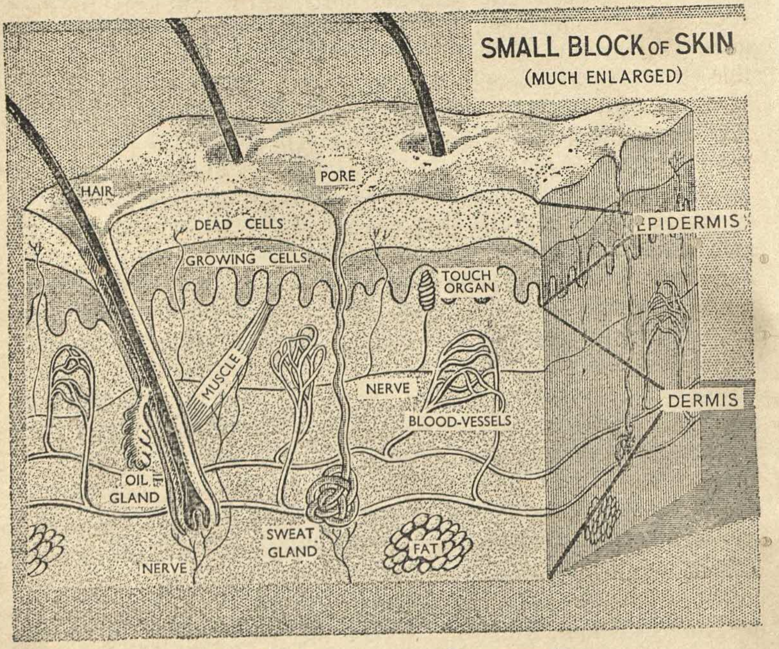


FIG. 40.—Skin structure (diagrammatic)

it is advisable to wear as few clothes as possible and to change them frequently, washing the clothes thoroughly with soap and then rinsing them in several changes of clean water until every trace of soap and dirt is removed. This final rinsing is very important because skin irritation may be caused by traces of soap or soda left in garments which come in contact with the skin. Ironing the clothes with a hot iron kills some organisms that cause skin troubles.

It is very important to keep the hair clean. It should be brushed and combed (using one's own personal brush and comb) every day to remove dirt and to increase the circulation of blood through the skin. Brushing also spreads the oil from the hair-glands along the hairs. The brush and comb should be washed every few weeks in cold water containing a little washing soda or ammonia, and then dried in the sun. A hair-brush should have stiff bristles,* set wide apart. When necessary, hair-brushes can be sterilized* by soaking in a weak solution of formaldehyde (e.g. one teaspoonful of 40 per cent. formalin in a pint of water). The hair should be thoroughly washed at frequent intervals with soap and warm water. If the hair is kept cut short, it is much easier to keep clean.

SKIN DISEASES

A number of skin diseases are caused by the invasion of the skin by *fungi.** Such diseases are particularly common in the tropics, where the high air-temperature is very favourable to their existence. *Ringworm* is a skin disease of this type, caused not by a worm but by the growth of a fungus between the inner and outer skin. The outer skin falls off in small scales, exposing lighter-coloured, scaly parts beneath. Another type of ringworm attacks the skin of the head, growing among the hair. Ringworm is very infectious and can be spread by direct contact or by the use of an infected person's hair-brush, hat, clothing, or towel.

*Dhobie itch** is a similar disease caused by the growth of a fungus in the skin.

Another fungus of the ringworm type invades the skin between the toes, and the infection is spread wherever people walk bare-foot, e.g. around swimming-pools and in the changing-rooms of sports buildings (hence the common name 'athletes'* foot' for this disease). This foot-itch can be very troublesome to cure, since the fungus may remain in the shoes, starting a new infection after the original foot-itch has been cured. The best protection is always to keep the feet clean and to dry them thoroughly after bathing, afterwards dusting with talcum* powder. Loose-fitting shoes or open sandals* (e.g. chaplis) help to keep the feet cool and dry.

All these fungus diseases are very difficult to cure once they have invaded the skin, since it is difficult to kill the fungus without also killing the surrounding skin, and they should be treated by a doctor as soon as possible.

Scabies

Scabies (or *the itch*) is a skin disease caused by a small animal—the *itch-mite*—about 0·3 mm. in length. The female itch-mite (see Fig. 41) bores under the outer skin, especially between the fingers, living in the skin and laying her eggs there. These hatch out in a few days and attack fresh areas of skin. Where the skin is thick, e.g. on the hands and feet, the track of the itch-mite can just be seen with the unaided eye as a fine raised line on the skin. Where the skin is thin, oval* spots and watery blisters* are formed. The skin itches so much that it is very difficult not to scratch. Scratching produces further trouble, since germs of other diseases may enter the skin, so that scabies is often the beginning of other skin diseases as well.

A person infected with scabies should go at once to a doctor, since very thorough treatment is necessary, and less than this is of no use. The patient's clothes, bedding, &c., must be disinfected by boiling or steaming. The itch-mite is usually transmitted from one person to another by direct personal contact, but it may also be picked up by handling infected clothing.

Yaws

Yaws is a disease of the tropics, commonest in children, caused by the invasion of the body by a microscopic spirochaete. Although the disease shows itself on the skin, it may spread to the rest of the body, affecting the bones and sometimes even destroying the bones of the face. Fortunately, yaws can be cured quickly and completely if early treatment is given. Yaws spreads mainly by personal contact, but little children may become infected by sitting unclothed on infected earth floors. The disease first appears as a small swelling which becomes covered with a yellow crust. This first outward sign of yaws is called the 'primary* yaw' or the 'mother yaw', and before it appears the patient will have suffered from headache, pains in the joints, and some fever. If no treatment is given, a large number of

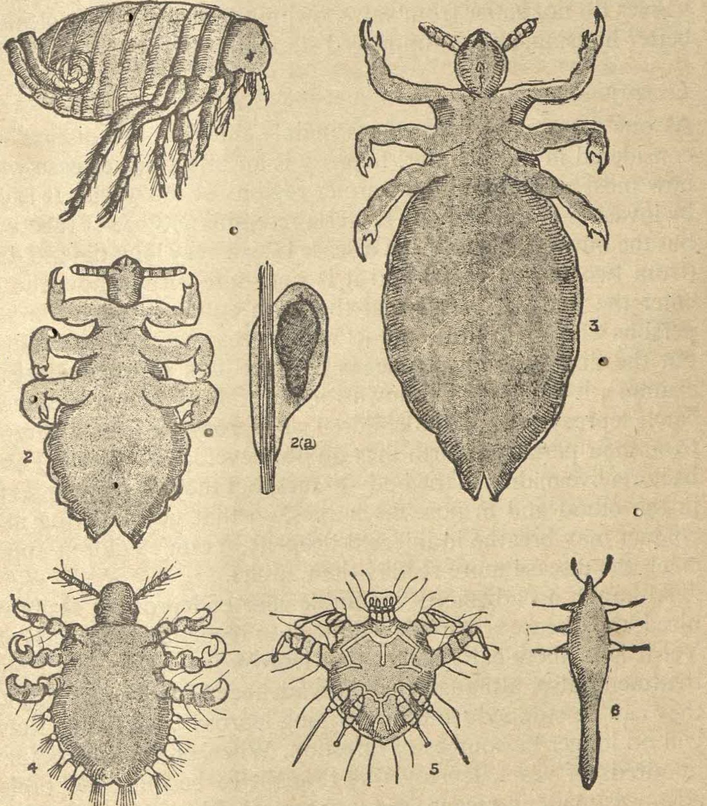


FIG. 41.—Some skin parasites of man

1—Flea (× 14). 2—Head-Louse (× 10). 2a—Egg of Head-Louse (× 10) cemented to a hair. 3—Body-Louse (× 14). 4—Crab-Louse (× 14). 5—Itch-Mite (× 50). 6—'Black-head' Mite (× 50)

'secondary yaws' appear six to twelve weeks later, accompanied again by fever, headache, and pains in the joints. This stage may last for months, and even for years.

The treatment of yaws is a matter for a doctor, and children suffering from yaws should be taken to a doctor at the first sign of the disease. With modern methods the disease can be completely cured.

It is very noticeable that the more highly civilized people in the tropics do not suffer from yaws, owing to greater bodily cleanliness, better housing, and an improved standard of living.

Leprosy

As one form of leprosy affects mainly the skin, the disease will be considered in this chapter. Leprosy is an infectious disease which is now most common in the warmer regions of the world. It is caused by invasion of the body by bacteria resembling those of tuberculosis, but the outward signs of the disease take a very long time to develop (from two to five years) and it is not quite certain how the germs enter the body. It seems that the germ enters through the skin of persons who are in close contact with leprosy patients for a long time, but the disease is by no means as infectious as tuberculosis. (For example, it is almost unknown for the staff of a leper-settlement to catch leprosy, and if the children of leprosy patients are removed from their parents at birth they do not develop the disease.) Leprosy bacteria live mainly in the body-tissues, but they are sometimes found in the blood and in nose-discharges, so that people living in close contact may breathe in infected droplets. Young children appear to catch the disease more readily than adults.

Although an advanced, incurable case of leprosy is easily recognized, the disease is extremely difficult to recognize in its early stages. Yet it is in these early stages that leprosy is curable. With modern treatment, also, although the more advanced cases cannot be cured, they can be stopped from discharging leprosy bacteria, so that they will no longer be sources of infection. When one considers that, for hundreds of years, leprosy was thought to be quite incurable, the advances made in recent years are remarkable.

In the most severe form of leprosy the bacteria are found chiefly in the skin, and this is the type of leprosy that spreads most readily. In its other form, the disease attacks the nerves, interfering with their working so that the affected areas become insensitive to pain, heat, and cold. The muscles also are affected, and the arms and legs may lose much of their power of movement (i.e. they become *paralysed**).

The modern method of fighting leprosy is (i) to isolate the advanced cases in comfortable and attractive leper-settlements, where they can get the best treatment, and keep them there until they no longer discharge leprosy bacteria; (ii) to treat early cases before they begin to discharge germs of the disease and become infective (many of these early cases can be completely cured, thus the root of the leprosy problem is attacked); (iii) to keep a careful record of everyone who has been in close contact with each new case of leprosy as it is discovered, and to examine these contacts every six months for five years. In this way, any new cases of leprosy will be discovered in the very early stages, when the disease is curable.

If these three methods could be combined in any area where leprosy is common, the ancient problem of rooting out leprosy would be almost solved in another twenty years.

Lice

Although the existence of *lice* on the skin is not actually a disease, they cause great discomfort and may carry the germs of disease. There are three kinds of lice which live as parasites on Man: (i) *body-lice*, (ii) *head-lice*, and (iii) *crab-lice* (see Fig. 41). In hot countries, body-lice are found usually only on people who wear much clothing; they are seldom present on lightly-clad people. All three kinds of lice have hooked claws* by means of which they cling tightly to hair and clothing. Body- and head-lice are very similar in size and appearance, and they vary in length from 1 to 4 mm. Crab-lice are much smaller, the body is squarer in shape and they remain still on one spot for a long time. Some of the mouth parts of a louse form a sucking-tube, while other mouth parts are used to pierce the skin.

After piercing the skin, the insect sucks blood. The bite of a louse causes itching, so that the victim scratches the skin, often producing sores which become infected with the germs of skin diseases. Besides this, lice may carry the germs of *louse-typhus* and of one kind of *relapsing fever*.

Lice are spread by contact with lousy people, clothing, bedding, brushes, &c., hence such contacts should be avoided. Personal cleanliness and frequent change of clothing also prevent lousiness, while if the hair of the head is kept short there is less risk of head-lice. Anyone with lice should have a hot bath and a complete change of clothing. If this is not possible, then DDT powder blown beneath the clothing will kill the lice (but not their eggs). The hair should be cut short and combed with a very fine comb which has been dipped in vinegar or soft soap to loosen the eggs. Since both lice and eggs are killed by moderate heat, infected clothing and bedding may be disinfected by baking at 70° C. for half an hour. Ironing with a hot iron is another simple way of killing lice in clothes. If typhus infection is suspected, then the lousy garments or bedding must be boiled or steamed to kill the rickettsiae that cause the disease.

Bed-bugs

The bed-bug is a small, flat, oval and wingless insect of a reddish-brown colour and about 0·5 cm. in length (see Fig. 42). It gives off a characteristic, unpleasant smell (particularly when crushed) and lives in joints and cracks in furniture and buildings, coming out only at night in search of food (usually human blood). With some people bug-bites cause itching and inflammation, resulting in loss of sleep. The female bug lays a total of about 200 eggs, 20–50 at a time, usually in joints and cracks in wooden furniture, and these eggs hatch out in about ten days. The young ones begin to suck blood at once if they find a human being. The females begin to lay eggs at six or seven weeks old, and they live for many months. It is very difficult to rid a house of bed-bugs without skilled assistance from the health authorities, who use a gaseous disinfectant, e.g. formaldehyde. Cleanliness of the house and person is an important means of prevention. Sprays have little *direct* effect owing to the difficulty of wetting the bug before it takes cover from the light, but if walls, beds, and other furniture are sprayed with DDT or BHC they can be kept free from bugs for several months.

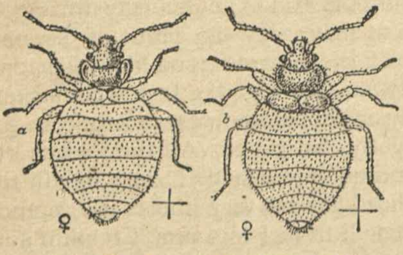


FIG. 42.—Female bed-bugs (× 5)

Bed-bugs can live for many months without food and they can walk from one house to another. Hence one must be always on the look-out for their first appearance, ready to destroy them before they breed and multiply. The top corners of mosquito-nets should be examined every morning when the net is raised, for this is their favourite hiding-place in the daytime. If no bugs are found here, then one can be fairly certain that the whole room is free from bugs. Holes and cracks in woodwork should be filled with paint (or even soap), and brick and stone walls should be whitewashed to fill all holes that might be used by bugs for hiding and breeding.

Bed-bugs may cause ill-health, producing such irritation and misery that a sick person cannot get well and a healthy person may become sick. In some countries, if an old house becomes over-run with bed-bugs, it is deliberately* set on fire and burnt, because there is no other way of dealing with bed-bugs once they are thoroughly established.*

Sandfleas—Chiggers

The chigger (also known as the *chigoe* or 'jigger') is a kind of flea that lives in sand or soil (and often in the earth floors of houses). The female insect, after fertilization, bores into the skin (usually under the feet) and lives there while her eggs develop, becoming several times her original size and producing a pea-like swelling under the skin. This causes an itching and burning pain so that it is difficult not to scratch. The chigger must be taken out whole so as not to infect the opening in the skin. This should be done very carefully with a clean needle (first sterilized by passing through a flame), and a mild antiseptic (e.g. iodine solution) should then be applied before the spot is covered with a clean dressing. People that do not wear shoes or sandals are obviously the most likely to get chiggers in their feet.

Ulcers

Among people living on a poor, badly-balanced diet, small skin injuries are usually slow to heal and often turn into painful *ulcers*. These *tropical ulcers*, which usually start near the ankle, soon spread over a large area of skin and may eat deeply into the flesh. Rest and proper medical treatment are necessary, together with an improved diet containing fresh fruit and vegetables, fresh milk, and vitamins A and D (e.g. in the form of red palm-oil, or fish-liver oil). To prevent the formation of tropical ulcers, even the smallest wounds on the feet and legs should receive prompt attention, being cleaned and treated with a mild antiseptic and then kept clean with a dressing held in position by sticking-plaster.

CHAPTER 7

THE CONQUEST OF DISEASE

We have seen that many diseases are 'catching', i.e. they spread from man to man or from animals to men. Examples of such *infectious* or *communicable* diseases* are the common cold, influenza, tuberculosis, typhoid fever, dysentery, ringworm, malaria, yellow fever, plague, the typhus fevers, tetanus, rabies, yaws, leprosy, and sleeping sickness. It is now known that all these diseases are caused by tiny living organisms of different kinds, and for convenience we often use one name for all such organisms and call them *germs*. But it is only during the last two or three hundred years that these microscopic germs have been recognized as causes of disease. Before that time, the *cause* of infectious disease was a complete mystery.

The first light was thrown on the problem about 300 years ago, when there was much argument about how living things arise. It was, of course, quite clear that the larger animals are the offspring* of their parents and that the larger plants arise from seeds. But no one knew the life-history of the smallest living things. Some people said that these very small living creatures arose from non-living matter, while others argued that *life can only come from life*, i.e. living creatures must be the offspring of previous living creatures of the same kind. This kind of *argument* had gone on for centuries, but it was not until about 300 years ago that any *scientific test*, or *experiment*, was carried out, and an Italian named *Redi* first showed that the maggots* which appear on decaying meat *did not come from the meat* (as most people then believed) but had hatched* out of eggs laid on the meat by flies. He showed that if fresh meat is protected from flies no maggots ever appear, no matter how long the meat is left. But this type of experiment could be used only for living things that are big enough to be *seen*, and it was not until the *microscope* was invented that still smaller living things (*micro-organisms*) could be seen.

About 250 years ago, *van Leeuwenhoek*, a Dutch scientist, discovered with the aid of the newly-invented microscope the existence of microscopic animals and plants, much too small to be seen by the unaided eye. About eighty years later, *Spallanzani*, an Italian scientist, actually saw one of these tiny one-celled micro-organisms divide into two. Then he saw these two divide into four, and so on, thus discovering that these tiny living things *reproduce themselves* and multiply like the larger plants and animals.

But it was nearly 100 years later (and less than 100 years ago) that *Pasteur*, a French chemist and one of the greatest scientists of all time, showed that even smaller living organisms, the *bacteria*, always arise from ancestors of the same kind, and he went on to prove experimentally that some diseases are caused by certain kinds of bacteria. Pasteur isolated the bacteria causing cholera in chickens and kept these bacteria alive and reproducing, *in culture*, in glass vessels in his laboratory. When he fed this cholera culture to healthy chickens, they very quickly developed cholera and died. Pasteur's great discoveries led to *the bacterial theory of infection*, and this laid the foundation for the great advances of modern medical science.

Pasteur made a further great discovery when he fed some old and weakened cholera culture to healthy chickens, which, although they became sick, *did not die*. When they had recovered, he gave them some fresh, active, cholera culture, but the chickens were unharmed. Pasteur had made them *immune to chicken cholera*.

Pasteur did similar experiments on *anthrax* (a common disease among sheep) and on *rabies* (see also p. 73). In both cases he prepared a *vaccine* which would give healthy animals immunity from the disease.[1]

In Germany, *Koch* was following up and improving on Pasteur's experiments by isolating, culturing, and *identifying* the bacteria which cause anthrax, tuberculosis, and human cholera, and it was Koch who finally proved that many infectious diseases are caused by micro-organisms. The work of Pasteur and Koch was soon taken up and extended in laboratories in other parts of the world, and the bacteria causing typhoid fever, dysentery, diphtheria, and pneumonia were soon discovered.

As the result of these great discoveries, medical scientists were able, at last, to plan their attack on infectious diseases. They now knew that they were faced with three main problems: (1) *How to stop these germs from entering the body of a healthy person;* (2) *how to kill the germs in a sick person's body without harming the patient;* (3) *how to help the human body to kill disease germs for itself.* You should now be able to think of examples of all three methods for fighting infectious diseases.

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[1] *N.B.* Although *Jenner* had discovered a method of *vaccination* against *smallpox* in 1798—long before Pasteur's time—neither he nor anyone else understood *why* it worked until Pasteur's work had led to the germ theory of infectious disease.

Infectious diseases, therefore, are caused by living germs that invade the body and multiply in it, feeding on it and living as *parasites* in the body-tissues. In most cases, it is the poisonous waste products (*toxins*) formed by such parasites that cause the ill-effects associated with each particular disease. In other cases the living parasites upset the structure and working of the body.

In the early days of the bacterial theory of infection it was thought that every infectious disease was caused by bacteria. But after their early successes with the diseases already mentioned, the bacteriologists were unable to isolate and identify the germs causing influenza, smallpox, yellow fever, measles, and rabies. They failed to find these germs simply because they were still smaller than bacteria, so that they escaped through the fine porcelain filters that stopped all bacteria. A *filter-passing germ* of this kind, too small to be seen under the most powerful ordinary microscope, is called a *virus.*[1] Unlike the disease-causing bacteria, the viruses will not grow and multiply outside the cells of their hosts, but they can be passed on from the sick to the healthy by the same means as bacteria. The name '*germ*', therefore, is applied to other disease-causing organisms besides bacteria, so when it was found that bacteria were not the only parasites causing infectious diseases, the bacterial theory of infection was widened into *the germ theory of infectious diseases.*

BACTERIA

Bacteria are the smallest known living things with a cellular structure. These colourless, one-celled micro-organisms (or *microbes*) exist wherever organic matter is found: in soil, in water, and in the air. Since most of them have no leaf-green (chlorophyll) they cannot use light energy in synthesizing their food, as do green plants, but they must get their food in other ways. In this, bacteria resemble animals, but since they are enclosed in a cell-wall they can only absorb dissolved food, thus resembling plants. But their cell-wall is not composed of cellulose, like plant cell-walls, and the modern view is that bacteria are neither plants nor animals, but form a separate class of living things.

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[1] Although viruses cannot be *seen*, they have recently been *photographed* by means of the new *electron-microscope.*

Single bacteria measure from 0·0001 in. to 0·00001 in. and can only be seen under very powerful microscopes. Different kinds of bacteria have different shapes, being either spherical, rod-shaped, or spiral, and they often group themselves together in masses or in straight chains (see Fig. 43). Many bacteria can swim in water. In all of them the cell is bounded by a membrane (but this is not made of cellulose) and the organism cannot take in solid food. Bacteria are found everywhere—in the air, on dust particles, in water, in the soil. Although most of them do not contain chlorophyll, some can make their own organic food from simple inorganic materials: they do not, however, use light energy for this purpose. Others get ready-made food from dead plants and animals. Still others are *parasites*; they are able to enter other living organisms and take food from them. In doing so they cause disease in, or the death of, their hosts.

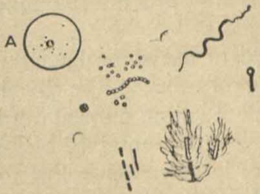

FIG. 43.—Types of bacteria (with a red blood-cell A to show relative size) (magnified about 1,000 times)

Bacteria reproduce themselves by splitting into two, and the two new bacteria grow so quickly that they are ready to divide again in about thirty minutes. Hence, in ten hours, a single bacterium can produce over a million bacteria. When conditions are unfavourable, e.g. when the liquid in which they are living dries up, some bacteria produce *spores*, and in this form they may be scattered in all directions, floating in the air, ready to germinate when they reach a suitable situation. These tough-walled spores are the most resistant form of living matter. Some bacterial spores have been known to germinate even after being kept in liquid air (at − 190° C.) for six months, but practically all spores are killed by boiling for twenty minutes.

Everyday importance of bacteria

Bacteria have a very important influence indeed on other organisms. Soil bacteria are partly responsible for the nitrogen and carbon cycles; in particular the nitrogen-fixing bacteria of the legume root-nodules* improve soil fertility. The breakdown of organic materials in soil largely benefits the higher plants and animals. The bacteria which live in the intestines of grazing* animals digest the cellulose in their food and in this way provide the animals (and themselves) with sugar.

Man has even learned to use some bacteria almost as 'domestic plants'. Thus the 'curing' of tobacco, the ripening of cheese, and the making of vinegar are all reactions carried out by bacteria. To Man, however, the bacteria are not an unmixed blessing. With the moulds and other fungi they are largely responsible for spoiling foods like milk, butter, eggs, and meat. Moreover, many of the important diseases of Man (e.g. tuberculosis, typhoid fever) have now been shown to be due to the activities of parasitic bacteria.

FOOD PRESERVATION

When we handle food in large quantities we must use methods which reduce the chances of its being spoiled by bacteria. In this way much waste can be avoided and, what is more important, the production of poisonous substances (toxins) in the infected food can be prevented. The most useful methods are:

(1) *Sterilization** of the food and its container by *heat*. Thus we heat fruit and vegetables just before bottling or canning them; we 'pasteurize' milk by heating it to not less than 142° F. for thirty minutes,[1] thus destroying most of the harmful bacteria. Canning and bottling have the additional advantage of excluding* air from the vessels. Few bacteria and no moulds can grow in the absence of oxygen.

(2) *Cold Storage*, which slows down the growth of all bacteria. Refrigerators are becoming more common each year in homes and

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[1] Or to 162° F. for 15 seconds.

food shops, and meat and other foods are transported round the world in ships fitted with refrigerators.

(3) The use of *fly-proof safes* and kitchens. Flies carry bacteria from place to place on their bodies; because they feed on refuse,* they are dangerous carriers of disease germs.

(4) *Desiccation.** Food to be used by people living at a distance from farms (e.g. by soldiers on service) is now often dried. This has two advantages—it reduces the weight of the food, while the lack of moisture prevents bacterial growth. If the drying is carried out properly, most foods preserve some at least of their valuable vitamins.

PREVENTION OF BACTERIAL DISEASE

It is not easy to prevent the entry of bacteria into the human body, where they may cause disease. In all modern civilized States the Health Departments do their best to reduce the chances of bacterial infection by:

(*a*) Ensuring a water supply free from dangerous bacteria; usually it is filtered and sterilized with chlorine.

(*b*) Ensuring a 'safe' milk supply; e.g. the milk is often 'pasteurized' to kill the bacterium causing tuberculosis.

(*c*) Safe disposal of sewage; e.g. the faeces of infected persons contain the bacteria causing *typhoid* and *dysentery*.

In hospitals today great precautions are always taken against bacterial infection, e.g. instruments and dressings are sterilized by heat just before use. If these methods fail, many of the recently discovered chemical substances like the '*sulpha*'-*drugs* and *penicillin* can be used to stop the growth of some kinds of bacteria without harming the patient. Some bacteria cause disease largely because they produce *toxins* in the blood; sometimes the body cures itself by producing an *anti-toxin*. The careful study of these and of the means of producing them gives the doctor yet another weapon in his fight against bacterial disease.

Disinfection

As so many diseases can only develop as the result of *infection* by disease-germs, it is clearly important to find ways of killing such disease-germs. *Disinfection* means the destruction of disease-germs, usually while they are outside the body, and a *disinfectant*, or disinfecting-agent, is something that actually kills germs. An *antiseptic*, however, only stops the growth and multiplication of germs and does not necessarily kill them. But this is very useful when we want to check the spread of infection from a wound to the rest of the body. In such cases, a strong disinfectant would kill the healthy cells as well as the harmful germs. A suitably mild* antiseptic checks the growth of germs without damaging the surrounding tissues.

The first proper use of antiseptics was made by *Lister*, a British surgeon, who, hearing of the discoveries made by Pasteur and Koch, realized that these had important applications to surgery. At that time, surgical operations were highly dangerous because most of the patients died—not during the actual operation but through 'blood-poisoning' which set in afterwards. Lister, suspecting that the pus produced in such cases was the result of bacterial infection, tried experiments in which everything used in his operations was soaked in a solution of carbolic acid (or phenol) which kills bacteria. No pus was formed after his operation, and the death-rate among surgical cases was remarkably reduced. Carbolic acid, however, although it *kills* germs also damages healthy tissues (it is a disinfectant rather than an antiseptic), so Lister tried milder chemicals strong enough to check the growth of bacteria without damaging the patient's tissues. This was Lister's *antiseptic* method, which completely revolutionized surgery and the treatment of wounds by preventing *sepsis* (infection of tissues with pus-forming bacteria). A still later advance was the *aseptic* method, designed to *exclude* germs completely from the exposed tissues. This is the method used in modern hospitals where the air, walls, and fittings of the operating theatre are kept free from dust and germs and where the outer clothing of the surgeon and his assistants is made *sterile* (or free from germs). Everything used in the operation, e.g. scissors, forceps, dressings, &c., is *sterilized* by steam before being used and is handled only by people wearing sterile rubber gloves.* The *aseptic* method is the ideal way to treat wounds, since it is obviously better to exclude germs than to try and destroy them after they have invaded the tissues.

Disinfecting-agents

It is convenient to classify disinfecting-agents as (i) *natural disinfecting-agents*, (ii) *physical disinfecting-agents*, and (iii) *chemical disinfectants*.

Natural disinfecting-agents

The natural disinfecting-agents are *fresh air* and *sunlight*, and we have learnt that most disease-producing micro-organisms soon die if they are exposed to air and sunlight. Out-of-doors, in fresh, moving air, it is almost impossible to 'catch' an infectious disease. Houses, therefore, should be well lighted and well ventilated. It is also a good practice to leave bedding and clothing exposed to bright sunlight for several hours each week. For example, typhoid bacteria are killed by exposure to strong sunlight for an hour or two.

Physical disinfecting-agents

Heat is one of the best disinfecting-agents, since most harmful bacteria are killed at 100° C. (the temperature at which water boils in an open vessel). Small articles that have been used by a sick person can be disinfected in the home by boiling in water for at least twenty minutes. The cheapest and most efficient way of applying heat to larger articles of clothing and bedding is by using *steam*, because steam at 100° C. contains more heat energy than does boiling water at the same temperature, e.g. when 1 g. of steam at 100° C. comes into contact with any material whose temperature is below 100° C. it sets free 536 gram-calories of heat energy in condensing to water at 100° C. This principle is applied in *steam-disinfectors*, which are of two main types: (*a*) *high-pressure disinfectors* using steam at a pressure of about 20 lb. per sq. in., and (*b*) *low-pressure disinfectors* using steam at about 5 lb. per sq. in. The high-pressure type is the more efficient (since it uses steam at a higher temperature), but it needs a skilled attendant to work it safely, hence this type is used mainly in large hospitals and in the public health departments of large cities. The low-pressure type requires less expert supervision, and the temperature it produces is not high enough to damage woollen articles. In both types of steam-disinfector, infected articles are placed in an iron chamber* (see Fig. 44) and the doors are tightly closed. Steam is then passed through the chamber under pressure.

In the high-pressure type, before steam is admitted air is removed from the chamber, thus producing a vacuum so that when steam is forced into the chamber at a high pressure it finds its way into all the spaces in woven materials formerly filled with air. After disinfection is complete, a vacuum is again produced in the chamber to remove as much moisture as possible from the disinfected articles.

A current of hot air is then passed through the chamber to complete the drying process.

In the low-pressure type, a *current* of steam is passed through the chamber, driving out all the air, so that the steam penetrates right inside the porous clothing or bedding material. The steam is turned off after half an hour, and hot air is then passed through the chamber to displace the steam and to dry the disinfected materials. Fig. 45 shows a small 'home-made' steam-disinfector suitable for use in places out of reach of larger and more complicated disinfectors.

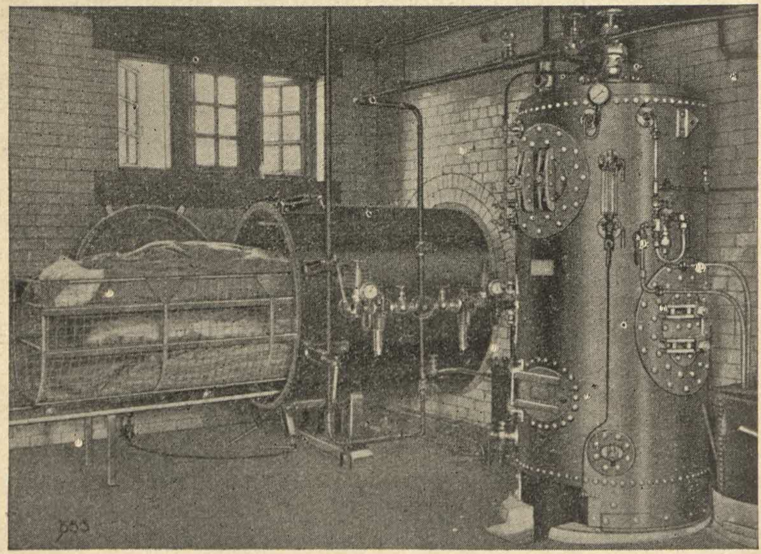

FIG. 44.—'Thresh' high-pressure steam-disinfector

The vertical boiler on the right supplies high-pressure steam to the horizontal disinfecting chamber on the left of the picture. The chamber is built into the wall separating two rooms. One room is used only for infected articles and the other room only for disinfected articles. Infected articles are put into one end of the apparatus and the disinfected articles are taken out of the other end, thus preventing re-infection

Chemical disinfectants

Chemical disinfectants are used either as gases or in solution. The commonest chemical disinfectants are (i) 'coal-tar' disinfectants, (ii) formaldehyde, and (iii) either quicklime or slaked lime.

(i) '*Coal-tar' disinfectants:* These are substances such as Cresol (1 per cent. solution), 'Lysol' (1 per cent.), and carbolic acid or phenol (5 per cent.). Infected articles can often be disinfected by soaking them in solutions of the above strengths.

(ii) *Formaldehyde:* Formaldehyde is a very powerful and very useful chemical disinfectant. It is a gas, but it is usually kept dissolved in water. 'Formalin' is a 40 per cent. solution of formaldehyde in water. A 10 per cent. solution of formalin is a very useful general disinfectant. It can be used for disinfecting urine, faeces, and sputum; it does not damage cotton, wool, or silk clothing, and it has no bleaching action. In fact, formaldehyde can be used to disinfect almost anything except leather (which it hardens).

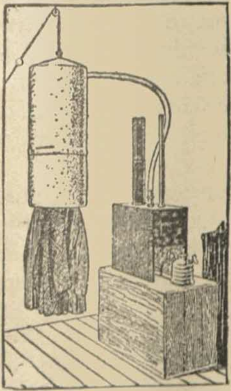

FIG. 45.—'Sack' steam-disinfector

Showing boiler, oil-burner, and clothing ready to be drawn up into 'sack'

Formaldehyde can also be used as a spray. It is much easier to disinfect a room by spraying the floor, ceiling, walls, and furniture with a 2 per cent. solution of formaldehyde than by using a gaseous disinfectant like sulphur dioxide. This spray method is particularly useful in tropical countries, where it is often difficult to make a room air-tight before disinfection.

(iii) *Lime:* Both quicklime and slaked lime are cheap and efficient disinfectants, hence the value of lime-washed walls and ceilings. Lime-wash is made by mixing one part of freshly slaked lime with about four parts of water.

For ordinary, everyday purposes, 2 per cent. formaldehyde is used for spraying, 1 per cent. Cresol (or 'Lysol') for washing infected clothes and bedding and for adding to lime-wash when whitewashing walls and ceilings.

In general, no disinfecting-agent can do its work unless it comes *into contact* with the micro-organisms which cause disease, and if these are protected by dirt much disinfectant is wasted. *Disinfectants can never serve instead of cleanliness. Remember that sunlight, fresh air, soap and water, and scrubbing are the oldest, best, and cheapest disinfecting-agents.* Disinfectants should not be used to hide bad smells, they must be applied directly to the bacteria which are producing the smell. Most stinks* are harmless in themselves; they merely indicate bacterial action somewhere in the neighbourhood.

Infected air should be removed by *ventilation*, since it is impossible to kill all the bacteria in air with disinfectants and still keep it fit for breathing.

In general, disinfectants are no substitute for cleanliness; for infection with the 'filth-diseases' arises mainly from *contact* with dirty hands and dirty drinking-cups and eating-vessels. The first essential is to attend to the people carrying the germs.

CHAPTER 8

PUBLIC HEALTH SERVICES

'Public health is the science and art of preventing disease and improving health through organized communal effort.'

Under primitive conditions, each separate family or group of families has to look after its health and sanitation without outside help. Under modern civilized conditions, with many people living close together in towns and villages, although each person can do much to keep his own body in good working order, there are many health measures* which are beyond the control of individuals. For example, it is of little use for one household to try to keep its compound* free from rats, flies, and mosquitoes if the neighbouring compounds are breeding-grounds for them. Also, in towns and villages, a person seldom knows the original source of all his food and how it has been prepared or handled before it reaches the market or shop. It is better (and cheaper) for the public health service to look after all those matters which prevent disease, and thus safeguard the health of the whole community.

In a modern civilized community, the public health service looks after the following: (i) *water supply*, (ii) *refuse disposal*, (iii) *purity of food supplies*, (iv) *control of housing conditions*, (v) *control of infectious diseases*, (vi) *registration of births and deaths*, (vii) *school medical inspection and child welfare*, and (viii) *health education* (in partnership with the schools).

WATER SUPPLY

A good supply of clean water for drinking, cooking, and washing is one of the first essentials for healthy living. There is seldom any difficulty about this in most large towns, where the water is purified and filtered before being supplied to houses. But in many country districts the water supply is not under proper control and may contain harmful impurities, e.g. parasites that cause disease. In some countries people use rain-water collected from house roofs and stored in tanks. This is not an ideal arrangement since birds (and sometimes rats) leave their droppings on roofs and in rain-water channels and thus contaminate the water. So, this rain-water should always be boiled before drinking it.

In many country districts, where there is no piped supply of purified water, the domestic water supply is obtained from lakes, rivers, or smaller streams. Such water should always be regarded with suspicion since it has usually been exposed to contamination. It is always risky to drink from a stream, for it may have been contaminated higher up in its course. The *appearance* of water is no guide to its suitability for drinking. A sample of water may be clear and sparkling to look at, and free from unpleasant taste or smell, and yet contain disease-bacteria and the organic matter on which they feed.

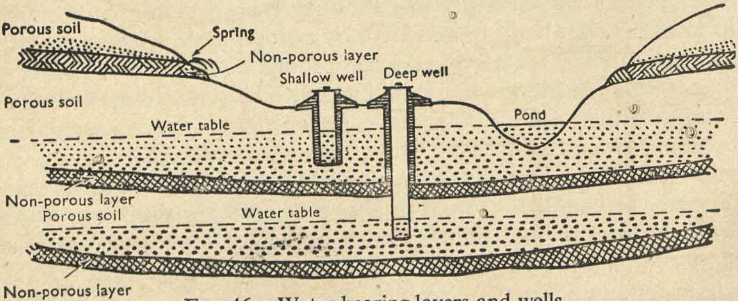

FIG. 46.—Water-bearing layers and wells

Water from *deep* springs and *deep* wells is usually free from suspended impurities (including bacteria) and safe to drink if the source is properly protected against contamination, e.g. there should be no latrine, cattle-shed, or manure heap within at least 100 ft. of the well. A spring should be built in with bricks, stones, and cement* (to exclude contaminated surface-water and dirt) and the water led away through a pipe into a covered tank from which water is taken by a pump (and *not* by dipping with a bucket*) or from an outlet-pipe fitted with a tap. In this way, the water cannot become contaminated between leaving the spring and reaching the supply-point.

Shallow wells or *water-holes* are always dangerous since they collect mainly surface-water and sub-soil water which has not been thoroughly filtered by passing through a considerable depth of earth (see Fig. 46).

A *deep* well, however, is one where the water reaches the well *from below* and not by drainage from above (see Fig. 46), because there is a non-porous layer of rock or clay between the water-level and the surface. The well should have a water-tight lining, e.g. bricks set in cement, or ready-made concrete* pipes of large diameter, extending down as far as the non-porous layer and projecting upwards two or three feet above ground level (see Fig. 47). The top of the well should have a close-fitting cover, and there should be a circular outward-sloping well-head of concrete at least 12 ft. in diameter so that if water is spilled near the well it will flow away to the side and not drain down through the soil near the well (see Fig. 48). The best arrangement is shown in Fig. 49, where a pump is used to raise the water without removing the cover from the well. This is a much safer method than lowering buckets into the open well, for one can never be sure that the buckets are clean. Well-water used for drinking and cooking should be tested periodically by the local health department.

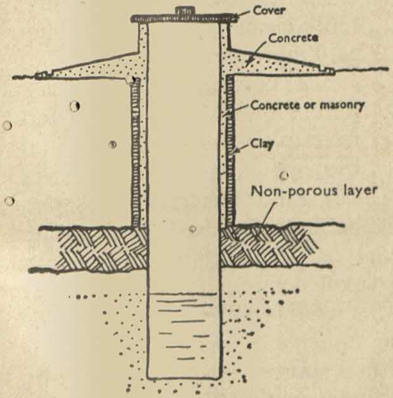

FIG. 47.—Deep well, simple type

The well passes through the first non-porous layer and the lining reaches that layer. The lining should be water-proof, to prevent entry of water from soil above the non-porous layer

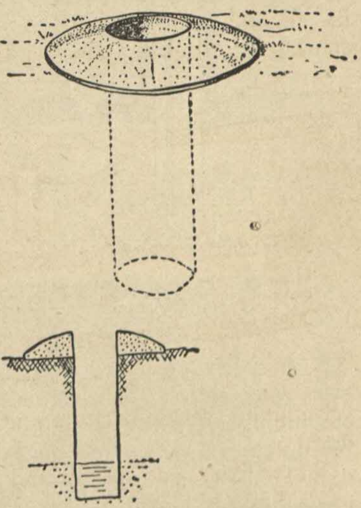

FIG. 48.—Well-head of concrete

Simple type to prevent drawn water from re-entering the well

The easiest and best way to make a small quantity of water safe for drinking, tooth-cleaning, and dish-washing, is to boil it for at least ten minutes. The use of household filters is not so safe as boiling, since if the filter gets dirty it will serve as a breeding-ground for disease organisms and will then do more harm than good. Hence if there is the slightest suspicion that a water supply is not 'good water', the best thing is to boil every drop of water used for drinking, tooth-cleaning, and washing cooking-vessels.

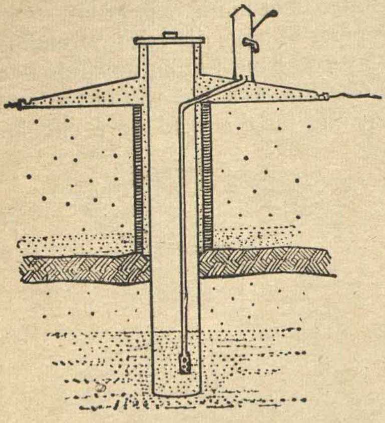

FIG. 49.—Deep well, with pump and cover

The common Chinese custom of always drinking tea and never plain water has a sound hygienic basis, since it ensures that the water is always boiled before being used for drinking.

A properly protected deep spring or deep well can provide a safe water supply for a family or small community, but in larger communities, e.g. towns and large villages, it is preferable to have one big public supply rather than large numbers of small wells. This is done by collecting water from a natural source situated in a near-by uninhabited *catchment-area* (e.g. a forest-covered valley running up into the hills), treating the water to make it safe and then distributing it through underground pipes. The public health authorities undertake the responsibility for seeing that the public water supply is pure.

Large-scale purification of water

There are usually three main processes used in treating town water supplies:

(i) *Settling* (*sedimentation**). The most dangerous impurities in water to be used for drinking and domestic purposes are *suspended* in the water and NOT dissolved in it. The water is first collected in large open tanks or reservoirs and left to stand quietly for several days, at least, while the heavier particles, e.g. fine mud and decayed

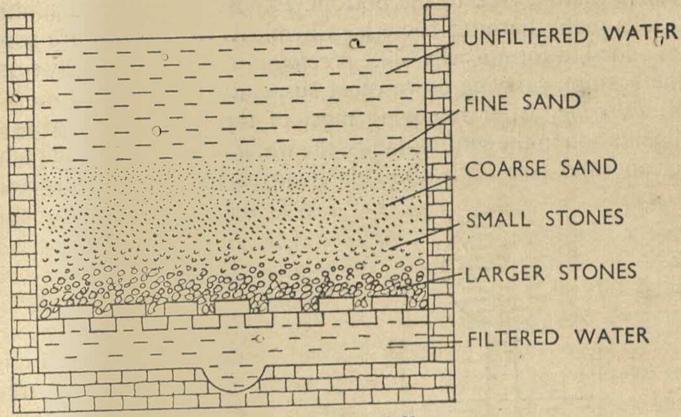

FIG. 50.—Sand-filter

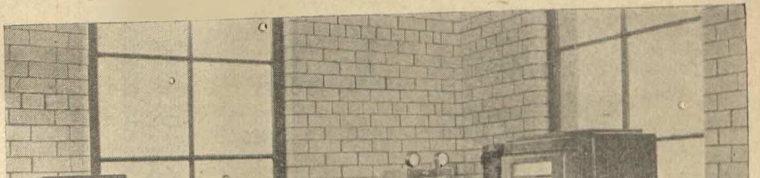

FIG. 51.—Chlorination plant at a city water-works

vegetable matter, sink to the bottom. Exposure to air and sunlight also kills many harmful bacteria. Chemicals (e.g. alum) are sometimes added to form a jelly*-like *precipitate** which gradually settles to the bottom, carrying down other suspended matter with it.

(ii) *Filtering*. After removing most of the suspended matter by sedimentation in the settling-tanks, the water is *filtered* through a bed of clean sand (see Fig. 50). This removes the smaller suspended particles (including bacteria) which did not fall to the bottom of the settling-tanks.

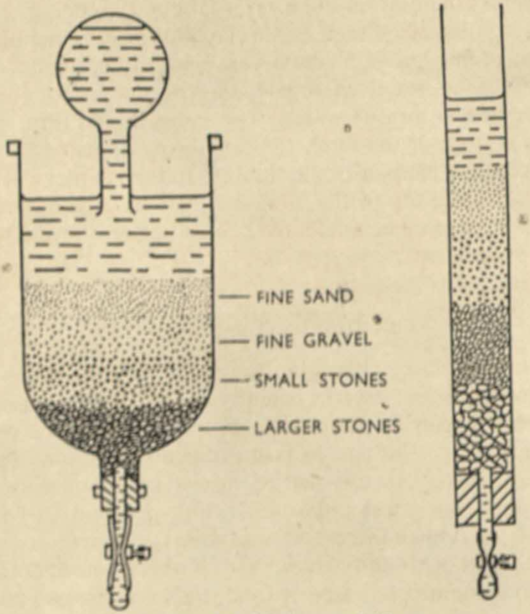

FIG. 52.—Model slow sand-filters

(iii) *Chlorinating*. To make quite sure that all bacteria are destroyed (in case any get through the sand-filters) the water is disinfected with *chlorine* (a poisonous greenish-yellow gas with a pungent smell), which kills bacteria (see Fig. 51). Only a small quantity of chlorine is needed: about one part of chlorine to every million parts of water. This is too little to do any harm to people drinking the water.

Water which has been passed through a well-organized water-works before distribution through supply-pipes is safe for drinking and all domestic purposes. Such a supply, regularly tested for purity and freedom from bacteria, protects the community against water-borne diseases like cholera, typhoid, and dysentery.

Set up a model slow sand-filter as shown in Fig. 52, using either an inverted bell-jar (or a large bottle with its bottom cut off) or a wide glass tube. At the bottom put a layer (about 2 in. deep) of pebbles* (about ½ in. diameter), then a 2-in. layer of smaller pebbles, then a 2-in. layer of fine gravel*, then a 4-in. layer of fine sand. (A layer of coarsely crushed wood charcoal* may be put below the sand to decolorize brown, peaty* water.) The water should drip *very slowly* from the bottom of the filter, the flow being adjusted by means of a spring-clip and piece of rubber tubing, and the model will not work perfectly until the top of the 'filter-bed' has become covered with a slimy 'vital* layer'. The model filter must not be allowed to dry out between experiments.

THE DISPOSAL OF WASTES

In his primitive state, when Man roamed* about the open country, he left his wastes and excreta behind him and moved on elsewhere. But as Man began to accumulate property and build permanent houses and villages he had to face problems of sanitation and the disposal of wastes. In any settled family or community—village, town, or city—the most important health problem to be faced is the disposal of human faeces, because so many human disease germs are passed out with the faeces, and if these infected faeces are allowed to contaminate water or food, then the diseases are spread.

Disposal of human excreta

There are several methods for the safe disposal of human excreta (i.e. faeces and urine) suitable for use under various living conditions: *pit latrines, bore-hole latrines, bucket latrines, septic tanks*, and *sewerage systems*.

Pit latrines

The simplest and cheapest way to dispose of excreta from a single family is to use a hole or pit in the ground. A pit latrine is quite satisfactory in well-drained, porous earth if it is dug deep enough, i.e. not less than 6 ft. (and more than 10 ft. deep if this is possible without reaching the ground-water level) (see Fig. 53). If the ground-water level is only a few feet below the surface, then a large mound* of tightly-packed earth should first be made, at least 6 ft. across and several feet high, and a pit then dug down through the centre of the mound to give the necessary depth. The pit should be covered with a

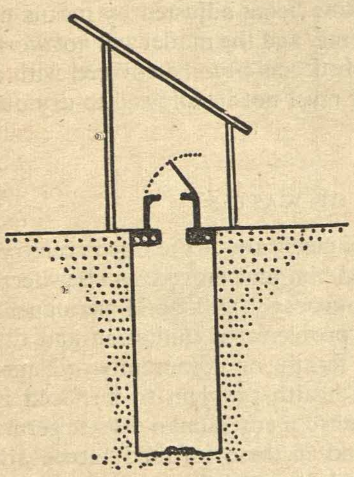

FIG. 53.—Pit latrine

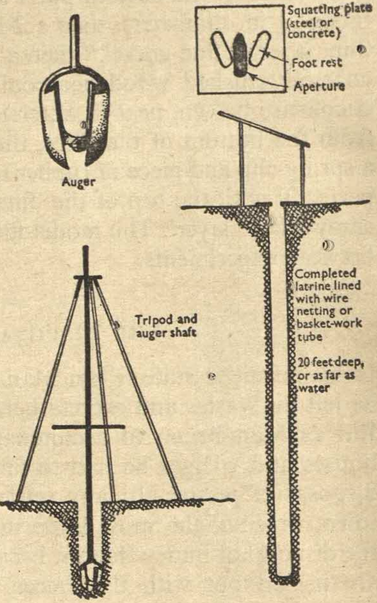
Squatting plate (steel or concrete)
Foot rest
Aperture
Auger
Tripod and auger shaft
Completed latrine lined with wire netting or basket-work tube
20 feet deep, or as far as water

FIG. 54.—Bore-hole latrine

strong wooden platform* fitted with a latrine box-seat and lid or (better) a squatting*-plate. Flies will not enter a deep, well-covered pit since they dislike darkness. A deep pit latrine dug in porous soil can be used by a family for several years, since it is self-cleansing owing to bacterial action which liquefies the faeces so that they gradually soak away into the surrounding earth. If the pit is too small for the number of users or if the soil is insufficiently porous it gradually fills up, and when about half-full it should be filled in with earth and a new pit dug some distance away (the earth dug from the new pit being used to fill up the old pit). A pit latrine should be in a light wooden building with an overhanging roof so that rain-water cannot enter the pit but is thrown clear, to be carried away by a drain surrounding the latrine.

Bore-hole latrines

These are made with a special boring-tool (or *earth-auger*) which cuts a hole 16 in. in diameter to a depth of 20 ft. or more if the ground is not too rocky (see Fig. 54). In practice, boring is stopped when the ground-water level is reached. If the surrounding soil is soft and crumbly,* the sides of the bore-hole can be prevented from falling in by a lining of basket-work or fine wire-netting, but when the surrounding soil is firm (e.g. laterite*) it is only necessary to line the top of the bore-hole with galvanized* iron to make cleaning easier. The top of the bore-hole should be closed with a concrete squatting-plate (with a lid), an arrangement which provides the most natural position for the user and which is more easily kept clean than a box-seat (see Fig. 54). A deep bore-hole of this type makes a most efficient latrine for a single family if the soil is suitable, for the latrine is almost self-cleansing and can be used for a very long time. Most public health authorities have the necessary earth-auger for boring the hole, and a small boring-team of men can make a deep bore-hole latrine in a few hours. Under suitable conditions of soil and situation, this is the best family latrine for country districts.

It should be borne in mind, however, that no pit latrine or bore-hole latrine should be less than 100 ft. from a well or other source of drinking water. Farther away than this is even better. To find out whether such a latrine is contaminating a near-by well, a strongly-coloured dyestuff (e.g. fluorescein) is poured into the latrine and samples of water are then taken from the well at hourly intervals. If the well-water becomes coloured then the latrine is contaminating the well, and a new latrine must be dug farther away or at a lower level. Kerosene (paraffin) is sometimes poured into the latrine instead of dyestuffs, and the taste and smell of the well-water shows whether the latrine is contaminating the drinking-water.

Bucket latrines

Pit latrines are suitable for small villages and country districts where there is room to make the latrines at some distance from houses. In larger villages and towns it is often necessary to collect the excreta and remove it for proper disposal. Under such conditions, the latrines are usually provided with buckets to receive the excreta (see Fig. 55). A small quantity of disinfectant is sometimes put in the bucket, and it is a good practice for the user to cover the faeces with a little dry earth to exclude flies. These buckets are removed (preferably in the early hours of the morning) and emptied or, better still, the bucket is replaced by a clean one and is removed in a special lorry fitted with closed compartments.* Such a system is expensive and requires very careful planning and supervision if it is to be satisfactory, e.g. it is often difficult to find labourers for this unpleasant job, and since the work is usually done before daybreak, supervision is difficult in the dark.

The excreta (or 'night-soil') collected in the buckets are usually disposed of by dumping* or *trenching*.* The trenching-ground should be at least half a mile away from the town or village, and the soil should be porous and well drained. Long, narrow trenches are dug, about 18 in. wide and 12–18 in. deep and about 18 in. apart. A layer of excreta, 3–6 in. deep, is put in the trench and then covered with earth. Under favourable conditions, decay is complete in a few months, but crops are not usually grown there for a year.

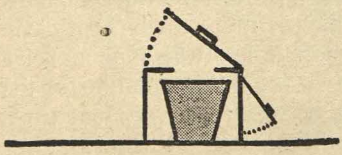

FIG. 55.—Simple bucket latrine

In some towns it is possible to empty the night-soil from bucket latrines into the sewers leading to a sewage-disposal works.

A very sanitary method for disposing of night-soil is to burn it in a specially-designed incinerator,* after mixing with dry refuse or other material. Unless plenty of dry refuse is at hand, however, incineration is very costly.

In some tropical countries, house and town refuse and excreta are disposed of by *composting*. This method has the practical advantage that it yields a product which is of great value as a manure for crops. Organic refuse is mixed with excreta and then left standing in a heap for about a week. Owing to the action of bacteria, the mixture soon gets hot, reaching a temperature of 140°–160° F. in the middle of the heap. At this temperature, any disease-producing bacteria and the eggs of intestinal worms are killed, and flies cannot breed. The compost heaps are turned at weekly intervals to admit air and to transfer the outer layer to the middle of the heap where it will become hot enough to kill unwanted organisms. The compost is usually ready for use as manure in about two months.

Septic tanks

When sewage (i.e. excreta mixed with waste water) is run into a closed tank, it is decomposed by bacteria which grow and multiply in the absence of oxygen. Large volumes of harmless gases are produced and the solid faeces are broken up. A thick scum* forms on the surface of the liquid, and mud settles to the bottom of the tank. This mud must be removed every few years. The liquid from the *septic tank* overflows on to a filter-bed of loosely-packed broken stone, where it is acted upon by bacteria which live in the presence of oxygen (see Fig. 56). The ammonia produced by the decomposition of protein material in the septic tank is finally oxidized to nitrates, and the liquid which flows out of an efficient septic tank and filter-bed is harmless and free from smell. As a further safeguard, this

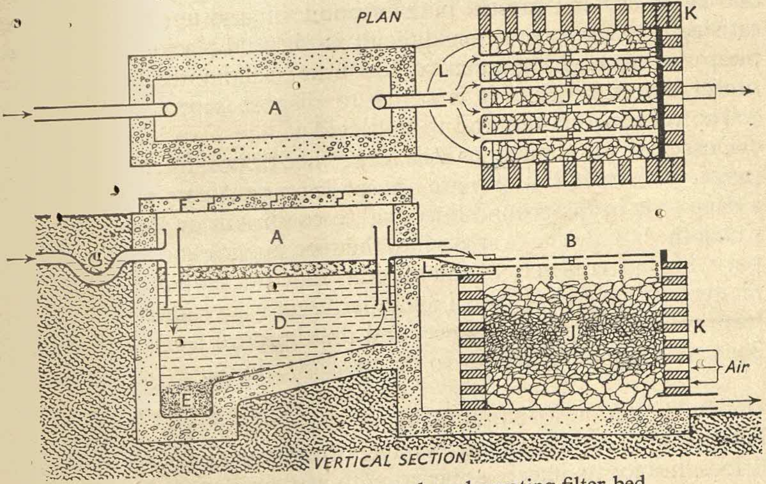

FIG. 56.—Section of septic tank and aerating filter-bed

A—Closed tank. B—'Filter' for oxidizing product from closed tank. C—Layer of scum excluding air. D—Sewage. E—Deposit of mud. F—Close-fitting covers for inspection and cleaning. G—Water-seal on inlet to prevent back-flow of gases. H—Distributing channels with loose-fitting joints. J—Loosely packed stone, forming 'filter-bed'. K—Walls of 'honeycomb' brickwork to admit air to 'filter-bed'. L—Distributor liquid is sometimes allowed to run down an open concrete drain exposed to air and sunlight. The design and construction of septic tanks requires expert knowledge.

When properly constructed and used so as to provide proper conditions for bacterial action, a septic tank does not produce unpleasant smells, because the bacteria in the closed chamber digest the solid matter in the sewage and destroy the harmful bacteria it contains. It is important *NOT to add antiseptics or disinfectants* to sewage which is to be treated in a septic tank, for this will destroy the useful bacteria present in the septic tank and upset its working, causing it to fill up too quickly with mud, thus blocking the outlet. Soap and grease have a similar action in checking the action of the useful bacteria, hence it is better to dispose separately of waste water from the kitchen and wash-place.

Cess-pools are sometimes used for sewage disposal because they are easy to construct, but they are not satisfactory. A cess-pool is simply a deep hole in the ground lined with loose bricks or stones through which the liquid sewage soaks into the surrounding earth. There is no purifying bacterial action, and the cess-pool quickly fills up with solid matter and has to be cleaned out at frequent intervals. The bad smell from a cess-pool is a nuisance, and the drainage from it may be a danger to any water supply in the neighbourhood.

Water-carriage sewerage systems

A septic tank is the simplest example of the water-carriage system of disposal, since the faeces are carried to the tank by the water which is used to wash down the squat-pan after use. The largest septic tanks, however, will only meet the needs of small communities of a few hundred people. For larger communities, e.g. modern towns and cities, the excreta, together with all waste water from washing and cooking, flow through drainpipes (called *sewers*) to *sewage-disposal works*. In most towns, rain-water from house and street drains also enters the sewers. Hence the sewage flowing through the pipes in a water-carriage system is mainly water (about 99·9 per cent.) carrying suspended and dissolved matter (about 0·1 per cent.). At the sewage-disposal works the sewage passes through metal netting screens* to remove any large solids, and then through tanks where the denser suspended mineral matter (e.g. dirt washed off roads, and sand used for cleaning cooking-vessels) settles to the bottom, while the less dense suspended organic matter passes on for treatment in the *settling-tanks*. The sewage flows very slowly through these settling-tanks so that the small, light particles of organic matter settle as mud before reaching the outlet. The liquid which runs out of the settling-tanks is further purified through oxidation by bacteria as it drips slowly over loosely-packed stone filters (as in the septic tank system) and is then discharged into a river or the sea.

The most difficult problem of sewage-disposal is how to deal with the organic mud left in the settling-tanks. One of the best methods is to allow the mud to be decomposed by bacteria, first in closed vessels and then in open vessels, for several weeks. The product has no smell and can be dried and used as a manure for crops.

REFUSE DISPOSAL

House refuse in tropical countries usually contains much damp vegetable matter which decays rapidly at such high temperatures, producing an unpleasant smell. It also provides food for rats and a breeding-place for flies. Hence it must be disposed of quickly—every day, if possible—before it becomes a nuisance.

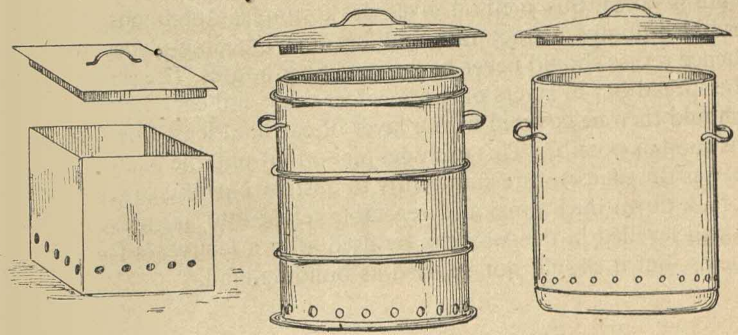

FIG. 57.—Sanitary dustbins

People living outside towns and large villages usually have to deal with their own house refuse, and the best method is to burn it each day, using a simple *incinerator*. This can be made out of an old oil-drum by cutting openings in the bottom and sides so as to admit plenty of air. The drum should be raised above the ground on bricks or stones and sheltered from the rain by a sheet of galvanized iron supported on a raised framework. A fire is started with dry material and the refuse is then added.

In towns and large villages, house refuse and street sweepings are collected and removed by the sanitary authorities. House refuse should be put into covered metal *dustbins*, which should be rat-proof and fly-proof (see Fig. 57). In tropical countries, this refuse should be collected every day, if possible, the dustbins being emptied into covered carts or lorries. There are several methods for disposing of the refuse after collection, the commonest being (*a*) *burning* and (*b*) *dumping*.

(*a*) *Burning*. This is the best method because the refuse is made harmless, but since house refuse in tropical countries usually contains a lot of wet vegetable matter it can only be burnt in properly designed incinerators or *destructors*. It is sometimes necessary to dry the refuse for a few hours before it will burn.

(*b*) *Dumping*. House and town refuse is sometimes used for filling up hollows and for raising the level of low-lying land. Unless great care is taken, this method gives rise to unpleasant smells, while the rubbish-dumps attract rats and become breeding-places for flies; hence refuse should never be dumped near houses. The refuse should be spread out in layers only a few feet thick and each layer of refuse should then be covered with a layer of earth, at least one foot thick, as soon as possible. This excludes air so that suitable bacterial action raises the temperature sufficiently to destroy harmful organisms and break down the animal and vegetable refuse into harmless material. Land levelled in this way can be used after a few years for playing-fields, but it should not be used as building-land.

HOUSING

We have learnt that Man's principal material needs are for *food*, *clothing*, and *shelter*. We shall now consider the last-named need, and how the health and comfort of people living in tropical countries are affected by their housing conditions.

The minimum housing accommodation needed in the tropics is (*a*) a room for shelter and sleeping, (*b*) a back verandah* for housework and cooking, (*c*) a front verandah for social life, (*d*) a small lock-up store, (*e*) a bathing-place and a place to wash clothes, (*f*) a covered place to keep dry firewood, (*g*) a latrine, and (*h*) an incinerator for burning rubbish.

Floors should be of hard material which does not wear readily to form dust, and they are easier to keep clean if not covered with mats,* rugs,* or carpets. In the same way, plain wood or cane furniture is better suited to tropical conditions than the padded and covered furniture commonly used in colder climates.

It is important that the site* chosen for building a house should be well drained, so that it does not become marshy* and malarial in wet weather. If no alternative position is available, then the house should be raised above the ground on pillars* and the earth under the house should be covered with concrete, if possible. In general, houses built on higher ground are drier and cooler since they catch more breeze. If possible the bedrooms should not be on the west side of the house, otherwise they become heated by the afternoon sun and remain hot for some time after sunset. A house should be surrounded by an open space to allow free movement of air round and through the house. A garden with small trees and plants will make the house cooler and a pleasanter place to live in, but large trees should not be allowed to overhang the house. Care should be taken that the trees have no holes in which rain-water collects. If it does, the holes should be filled with concrete. Bamboo often retains water and breeds mosquitoes in its hollow stems where these have been cut or broken off.

Bricks, stone, and concrete are the best materials for building the walls, although wood and galvanized iron are often used. If wood is used, it should either be 'hard wood' or be treated with chemicals to keep out termites ('white ants'). A 'damp-proof' layer should be laid in all brick or stone walls about 6 in. above ground level. This consists of a waterproof layer of pitch,* zinc, or glazed brick, to stop water rising through the wall by capillarity. Sheets of galvanized iron are sometimes used for this purpose, with the outer edge extending outside the building so as to stop rats from climbing up the walls. If the walls are limewashed outside, they will absorb less heat from the sun.

Verandahs help to keep houses shady and cool, but they should be at least 10 ft. wide if they are to protect the house-walls from the direct rays of the sun. There should be enough window-space to let in plenty of light and air, and it is a great advantage to have window-openings on two opposite sides of every room to allow a through current of air for ventilation. Inside walls should be painted or colour-washed in light colours. A badly-lighted and badly-ventilated room with dark-coloured walls will tend to become dirty because it is so difficult to see the dirt.

The commonest roofing materials are thatch,* tiles,* and galvanized iron. Thatch is cheap and cool, but it may shelter rats and insects, and there is also danger from fire in dry weather. If covered with fine wire-netting, however, thatch can be made rat-proof. Tiles are a very satisfactory roofing material, but they should be properly laid so as to leave no nesting-places for rats. Galvanized iron is cheap and easily fixed in place, but an iron roof is very hot in the daytime unless properly ventilated, e.g. with a ridge-ventilator. A wood or asbestos ceiling below the iron roof makes the house much cooler, particularly if sheets of thin, polished, aluminium foil* are laid on top of the ceiling to reflect back the heat. Rain-water channels round the edges of a roof may be dangerous in tropical countries because they may hold water in which mosquitoes can breed. Channels are necessary where rain-water has to be stored for domestic use, but care should be taken that they do not become blocked up, e.g. with dead leaves, and that they do not bend between the supports. If it is not necessary to collect the rain-water, it is safer to do without channels round the lower edge of the roof, and to allow the rain to drop direct into a concrete drain surrounding the whole building. In order to throw the rain-water clear of the outer walls, the roof should continue at least 2 ft. beyond them.

When there is a plentiful supply of water for domestic purposes, special arrangements are necessary for getting rid of used water. In large villages and towns there is usually a system of street drains into which house-drains discharge. Where houses are far apart and where there are no public drains, then a *soak-pit* may be used to receive waste water from kitchen, bathing-place, and wash-place. This water flows through drain-pipes into a long narrow pit, dug in lower ground some distance from the house and packed with broken stone or similar material. The waste water gradually soaks away into the surrounding soil, well away from the house. A roof of concrete slabs,* covered with earth and grass, hides the pit and prevents mosquitoes from breeding in it.

In towns, no building may be built or any change made in it until the plans have been inspected and approved by the public health authority. This ensures that houses shall be properly built and free from dampness, that the rooms are large enough, well lighted, and well ventilated. There must also be proper water supply, drains, and latrines. Some countries have Town Planning Departments to see that towns are arranged so as to be healthy places to live in. Certain areas are usually reserved for dwelling-houses, and other areas for factories. Public gardens, parks, and playing-fields are planned so that every citizen is within easy reach of an open space for exercise. The road system is carefully planned so that it is easy to get from one part of the town to another, and also so that light and air reach every building. Town-planning also provides for re-housing people living in the older, crowded parts of the town, under unhealthy conditions, by building new houses in better situations.

FOOD PURITY

The public health service also looks after the purity of the food supply by controlling and inspecting markets, abattoirs,* bakeries, dairies, and any other places used for the preparation, sale, or storage of food.

People that produce their own food from farms and gardens can control its cleanliness for themselves, but in many modern communities people cannot produce their own food supply and have to depend on others for it. Under such conditions, the user seldom knows how the food was grown, stored, and handled before he buys it in the shop or market, so in well-organized communities the public health service controls the handling and distribution of food (including milk).

Sanitary inspectors have authority to take a sample of any foodstuff offered for sale and to send it to the laboratory for examination. They pay particular attention to the inspection of meat and milk, including the methods of producing and distributing the latter. Some sanitary authorities also examine dairy animals for signs of tuberculosis.

To protect the health of the community, all civilized countries have *pure food laws* providing punishments for those people who try to sell inferior* or contaminated food.

The public health department also controls food markets, seeing that the stalls are properly constructed and washed down with plenty of clean water at frequent intervals. Market inspectors also see that waste matter is properly disposed of, so as to keep the market and its surroundings free from rats and flies.

CONTROL OF INFECTIOUS DISEASES

In most tropical countries people are obliged by law to report to the public health authorities any cases of infectious diseases, e.g. plague, cholera, smallpox, chicken-pox, diphtheria, measles, and typhoid. The health authorities then arrange for the isolation of the patients and for the disinfection of houses and their contents. People who have been in contact with the patients are isolated or kept under observation, while the health authorities also try to discover the original source of the infection and to deal with it. Vaccination against smallpox is usually compulsory and is carried out by the public health authorities. The compulsory muzzling of dogs to prevent the spread of rabies is also organized by the public health authority. Special care is taken at sea-ports and border stations to prevent the entry of infectious diseases from foreign countries. If a ship arrives with cases of infectious disease (e.g. cholera, plague, or smallpox) on board, or arrives from an infected port, the port health authority has the ship disinfected and keeps the passengers in quarantine until it is known that they are free from infection. In tropical countries, the public health service is largely concerned with preventing the spread of malaria, mainly by anti-mosquito work and free treatment with drugs.

REGISTRATION OF BIRTHS AND DEATHS—VITAL STATISTICS

Just as commercial book-keeping shows the state of a business, so *vital statistics** reflect the state of health in a community. In order to measure the effect of public health work, most countries make it compulsory* to register births and deaths. For example, if the number of deaths per thousand people in a district is much higher than usual, then the public health authorities look for the cause. Since it is necessary on registration to state the cause of death, the health authorities can tell which diseases are being controlled and which need better preventive measures. Registration of births and deaths also enables the public health authorities to measure the *infant death-rate*, i.e. the proportion of babies who die before they are one year old. Since most of these infant deaths are preventable, the infant death-rate is a very good guide to the local health conditions —the lower the infant death-rate the healthier the district.

INFANT WELFARE AND SCHOOL MEDICAL SERVICES

The aim of these public health services is to check the beginnings of ill-health in young children. Many grown-up people suffer ill-health because small defects were not treated when they were children. If every schoolchild is examined once a year by a doctor and a dentist, these small defects can be discovered and can receive skilled treatment. Many young children suffer from health defects before they begin going to school, and Infant Welfare Centres aim at making children healthy in the first few years of their lives. Since a baby's health in its youngest days depends on its mother, most countries have health centres where mothers can get expert advice about their own health and that of their babies.

PUBLIC HEALTH EDUCATION

Public health work can only succeed through willing and understanding co-operation by members of the community who understand the reasons which underlie the study and practice of hygiene. This health education, as a part of the ordinary education of every boy and girl, should consist not merely in learning facts about personal health, but also in practical training in the habits of healthy living. Many people who have been 'taught hygiene' at school may understand the subject from the theoretical point of view and pass written examinations in hygiene without *using* the principles they have learned, to attain and maintain good health for themselves. Although the public health authorities can compel people by law to carry out certain health measures, they are always unwilling to make use of such powers. Willing and understanding co-operation is much better than compulsion, and if the author has helped to prepare you to co-operate in this way after you leave school then this book will have realized its main aim.

[illegible]

APPENDIX A

FOOD TABLES

The food tables that follow are designed to help in planning practical everyday diets with natural foods that are commonly available in tropical countries. Table I summarizes the daily nutritional requirements of people of varying age, sex, and occupation. Tables II–VIII provide a guide to the selection of suitable protective foods. The teacher should also have available at least one copy of a complete set of tables showing the composition of commonly used foods, e.g. B. S. Platt, *Tables of Representative Values of Foods Commonly Used in Tropical Countries* (Medical Research Council, Special Report Series No. 253. Published by Her Majesty's Stationery Office at 1*s*. 6*d*.). Most of the figures given in Tables II–VI have been taken from this source.

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TABLE I

DAILY NUTRITIONAL REQUIREMENTS

The following recommendations are based on the scientific knowledge of 44 nations represented at a United Nations Food Conference. They have been used all over the world as a guide in nutritional work.

(The letters in brackets refer to the notes on the opposite page.)

						Vitamin B			Vitamin C	
	Calories (*a*)	Protein (gm.)	Calcium (gm.)	Iron (mg.)	Vitamin A (*b*) (I.U.s)	Thiamine (*c*) (mg.)	Riboflavin (*c*) (mg.)	Nicotinic Acid (*c*) (mg.)	Ascorbic Acid (mg.)	Vitamin D (I.U.s)
Man (156 lb. = 70 Kg.)										
Sedentary occupation	2500	70	0·8	12(*d*)	5000	1·2	1·6	12	75	(*e*)
Moderately active	3000	70	0·8	12(*d*)	5000	1·5	2·0	15	75	(*e*)
Very active	4500	70	0·8	12(*d*)	5000	2·0	2·6	20	75	(*e*)
Woman (125 lb. = 56 Kg.)										
Sedentary occupation	2100	60	0·8	12	5000	1·1	1·5	11	70	(*e*)
Moderately active	2500	60	0·8	12	5000	1·2	1·6	12	70	(*e*)
Very active	3000	60	0·8	12	5000	1·5	2·0	15	70	(*e*)
Pregnant	2500(*f*)	85	1·5	15	6000	1·8	2·5	18	100	400–800
Lactating	3000	100	2·0	15	8000	2·0	3·0	20	150	400–800
Child (up to 12 years) (*g*)										
Under 1 year (*h*)	100/Kg.	3·5/Kg.	1·0	6	1500	0·4	0·6	4	30	400–800
1–3 years (29 lb. = 13 Kg.)	1200	40	1·0	7	2000	0·6	0·9	6	35	400
4–6 years (42 lb. = 19 Kg.)	1600	50	1·0	8	2500	0·8	1·2	8	45	400
7–9 years (55 lb. = 25 Kg.)	2000	60	1·0	9	3500	1·0	1·5	10	60	400
10–12 years (75 lb. = 34 Kg.)	2500	70	1·2	10	4500	1·2	1·8	12	75	400
Girl (over 12 years) (*g*)										
13–15 years (108 lb. = 49 Kg.)	2600	80	1·3	15	5000	1·3	2·0	13	80	400
16–20 years (119 lb. = 54 Kg.)	2400	75	1·0	15	5000	1·2	1·8	12	80	400
Boy (over 12 years)										
13–15 years (103 lb. = 47 Kg.)	3200	85	1·4	15	5000	1·5	2·0	15	90	400
16–20 years (141 lb. = 64 Kg.)	3800	100	1·4	15	6000	1·8	2·5	18	100	400

(*a*) All these figures show what to aim at in planning practical diets with natural foods. Such a diet will also provide other mineral salts and vitamins whose precise requirements are less fully understood.

(*b*) This requirement depends upon the relative amounts of vitamin A and carotene. The figures in the table assume that approximately two-thirds of the vitamin A allowance comes from carotene and that carotene has about half the protective value of vitamin A. (I.U.'s = International Units.)

(*c*) For adults (except pregnant* and lactating* women) on diets supplying 2,000 Calories or less, the allowance of thiamine, riboflavin, and nicotinic acid may be 1 mg., 1·5 mg., and 10 mg. respectively. The fact that different figures are given for thiamine, riboflavin, and nicotinic acid for different Calorie levels does not mean that we can estimate the requirement of these accessory food factors so closely, but they are given merely to make calculation easier. Other vitamins of the B group are also required, although no precise figures can be given in the table, but a diet supplying sufficient thiamine, riboflavin, and nicotinic acid will usually supply adequate amounts of the other B-group vitamins.

(*d*) There is now evidence that the adult *male* needs less iron than was formerly believed to be necessary. If the diet is satisfactory in other respects there will also be sufficient iron.

(*e*) Adults who are seldom exposed to clear sunshine may need small amounts of vitamin D. Other *adults* need very little vitamin D in the tropics. (I.U.'s = International Units.)

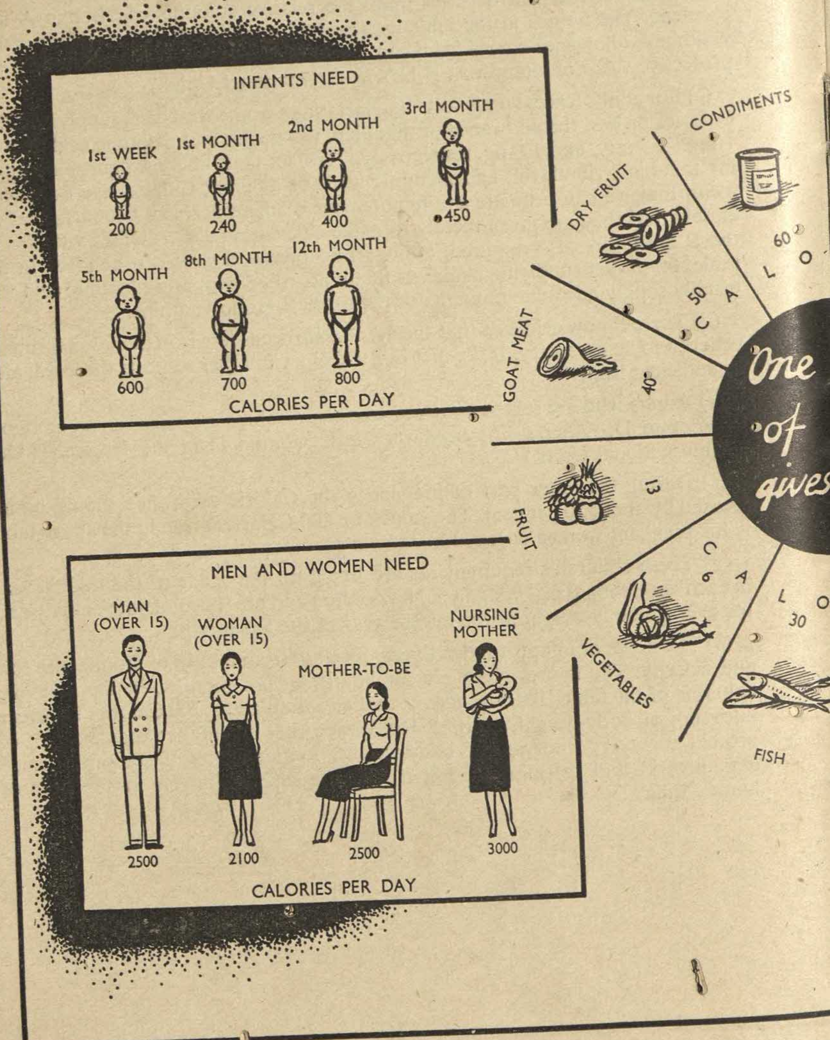
(*f*) During the latter part of pregnancy the Calorie allowance should be increased by about 20 per cent. The value of 2,500 Calories given in the above table is for pregnant women engaged in *sedentary** occupations.

(*g*) These children's requirements are based on the needs of the middle year in each age-group (i.e. 2 yrs., 5 yrs., 8 yrs., &c.) and are for moderate activity and for average body-weight at the middle year of the age-group.

(*h*) The needs of infants (under 1 year) increase from month to month with size and activity. The figures given are for infants of 6–8 months. In the first two columns of the table, 100/Kg. means that an infant needs 100 Calories for every kilogram of body-weight, and 3·5/Kg. means that an infant needs 3·5 gm. of protein for every kilogram of body-weight. Requirements of some nutrients* (e.g. protein and calcium) are less if they are supplied largely in the form of human milk.

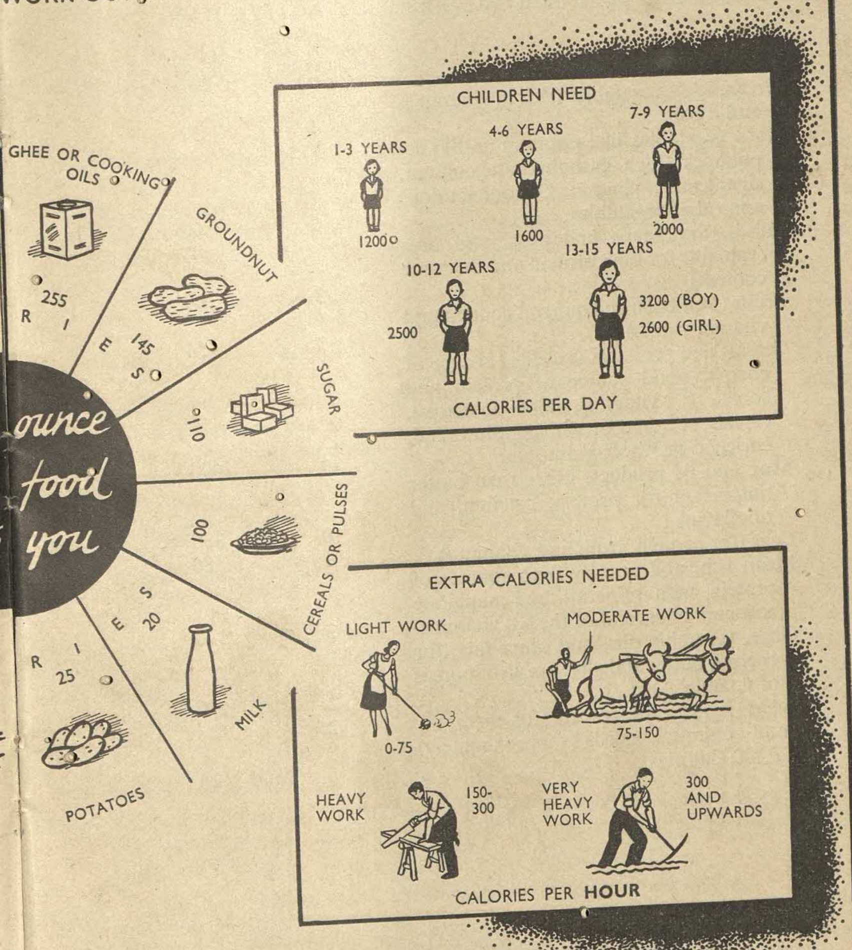
CALORIE

TAKE A PENCIL AND PAPER AND WITH THE HELP OF THIS CHART TRY TO



CHART

WORK OUT WHETHER YOUR OWN MEALS SUPPLY YOUR CALORIE NEEDS



SPECIMEN DIET FOR MODERATELY ACTIVE MAN

Food groups	Approx. daily requirements (ozs.)	Approx. No. of Calories
Green, leafy vegetables (rich in vitamin A and iron)	4	52
Root vegetables like potatoes and sweet potatoes (high carbohydrate content, significant* vitamin C contribution) and other vegetables . . .	6	60
Pulses, dry beans and peas, and nuts (valuable for high protein and thiamine content)	3	300
Fruits (well-balanced mineral content and vitamin values)	3	54
Cereals and products (excellent source of energy, good source of protein and some 'B' vitamins, also minerals), cereals, restored or whole-grain bread, enriched or whole-grain flour . .	14	1400
Milk and its products other than butter (important for protein, calcium, and riboflavin)	10	330
Eggs (for protein, iron, and vitamin A)	1	86
Meat, fish, and poultry (rich sources of protein with minerals and moderate amounts of several of the 'B' vitamins)	3	120
Ghee, vegetable oils, and other fats (for energy; butter and ghee are also sources of vitamin A)	2	500
Sugar, jaggery, and sweets (for energy) .	2	224
Total essential needs (approximately) 3,000 Calories		Total 3126

TABLE II

FOODS RICH IN VITAMIN A

(For daily requirements of vitamin A, see Table I)

The figures given below indicate the number of *International Units present in 100 grams of edible material.* (In the case of fruits and vegetables and any other foods containing both vitamin A and carotene, the 'vitamin A value' includes an allowance for the carotene they contain, since carotene is converted into vitamin A in the body.) Low-value products are shown in brackets for comparison.

ANIMAL PRODUCTS	
Liver	27000
Kidney	1000
Eggs	1000
Milk, cow's, fresh	100–140
Milk, condensed, sweetened	400
Milk, condensed, unsweetened, evaporated	400
Milk, dried, whole	1400
(Milk, dried, skimmed	60)
Butter	2700
Ghee (clarified butter)	2500†
Cheese	1400

PLANT PRODUCTS	
Papaya (Pawpaw)	2500
Tomato	1200
Mango	1000
Banana	350
Pineapple	200
Orange	250
Red Palm Oil	40000–80000
Carrot	13000
Sweet Potato, root (*red*)	7000
Green Leafy Vegetables [1]	13000
Beans, eaten green in pod	600
Beans and Peas, eaten green, shelled	400
Betel leaves	9500
Onion, young, eaten with leaf	3000
Lettuce	2000
Leek	700
Cucumber	200
Ladies' Finger (Okra)	1000
Pumpkin (Squash), yellow	1100
Peppers, green, fresh	1000
Peppers, red, fresh	18000

Foods lacking in vitamin A value

Cereals. Salt fish. Beef. Mutton. Pork. Poultry. Vegetable fats and oils (except red palm-oil). Margarine.[2] Goat fat. Pig fat (including bacon-fat). Lard. Skimmed milk.

† May be much lower, depending on the method of preparation.

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[1] e.g. dark green leaves of spinach (Amaranth), sweet potato, mustard, cassava, pumpkin cow-pea.

[2] Some margarine contains added vitamins A and D.

TABLE III

FOODS RICH IN VITAMIN B_1

(For daily requirements of vitamin B_1, see Table I)

The figures given below indicate the number of *milligrams of vitamin B_1* (thiamine or aneurin) *present in 100 grams of edible material*. Low-value products are shown in brackets for comparison.

PLANT PRODUCTS	
Rice, brown, lightly milled	0·24
(Rice, white, polished	0·06)
Rice, parboiled	0·21
Rice Polishings	1·2
Rice Bran	0·5
Maize, whole grain, yellow	0·33
Maize Meal, whole	0·3
(Maize Meal, highly refined	0·05)
(Maize Starch, 'cornflour'	0·00)
Maize, sweetcorn, green mealies	0·15
Millet, bulrush	0·5
Millet, finger	0·28
Oatmeal	0·5
Rye Flour	0·27
Sorghum	0·5
Wheat, whole grain	0·4
Wheat Flour, wholemeal, atta	0·3–0·4
Wheat Flour, white	0·06
(Arrowroot	0·00)
Potato, English/Irish	0·1
Potato, sweet	0·1
Bambara Groundnut	0·3
Cow-pea	0·9
Groundnut (Pea-nut), dry	0·9
Kidney Bean (French Bean)	0·45
Lentil (red dhall)	0·65
Lima Bean (Butter Bean)	0·53
Grams, red, yellow, green and black	0·45
Soya Bean	1·12
Sesame (gingelly), seed	0·42
Yeast, baker's	3
Yeast, brewer's	16
Yeast, food	2

ANIMAL PRODUCTS	
Pork, lean, fresh	1
(Beef	0·09)
(Eggs	0·14)
(Mutton, sheep, or goat	0·20)
(Poultry	0·15)
(Milk, cow's	0·04)
(Cheese	0·04)
(Fish	0·05)

Foods lacking in vitamin B_1 value

White, polished rice, and other 'refined' cereal products, e.g. white flour and white bread. Cassava (tapioca) flour. Meat (except pork). Fish. Milk and cheese.

TABLE IV

FOODS RICH IN VITAMIN C

(For daily requirements of vitamin C, see Table I)

The figures given below indicate the number of *milligrams of vitamin C* (ascorbic acid) *present in 100 grams of edible material.*

PLANT PRODUCTS

Fruits, fresh	
Guava	200
Indian Gooseberry	600
Lime	25
Orange	45
Passion Fruit (Grenadilla)	20
Papaya	30
Melon, sweet	35
Avocado Pear	20
Cape Gooseberry	30
Pineapple	30
Tomato	25
Banana	10

Vegetables, fresh [1]	
Green Leafy Vegetables [2]	100
Persimmon leaves, fresh	2700
Persimmon leaves, dried	3500
Peppers, sweet, green	200
Peppers, sweet, red	350
Beans, eaten green in pod	20
Beans and Peas, eaten green, shelled	25
Ladies' Finger (Okra)	25
Onion, young, eaten with leaf	20
Leek	20
Cassava (tapioca), tuber	30
Potato, English, Irish	15
Potato, sweet	20
Maize, sweetcorn, green mealies	10

Foods lacking in vitamin C value

Cereals and cereal products. Most starchy roots. Most dried fruits and vegetables. Dried peas and beans. Meat. Eggs. Milk. Jam. Green vegetables *cooked with soda.*

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[1] Vitamin C value much reduced by cooking.

[2] e.g. dark green leaves of spinach (Amaranth), sweet potato, mustard, cassava, pumpkin, and cow-pea.

NOTE ON VITAMIN D REQUIREMENTS

No separate table is given here to show foods rich in vitamin D (calciferol) since many of the foods listed in Table II as good sources of vitamin A also supply vitamin D, e.g. animal fats like fat meat, fat fish, eggs, milk and butter. Also, as mentioned on p. 20, green leaves contain small quantities of ergosterol, which can be converted into vitamin D in the human body, so that if the diet includes sufficient green leafy vegetables then the vitamin D requirement will also be satisfied (provided that the skin gets some sunlight). Serious vitamin D deficiency can be remedied by the use of fish-liver oils and by the use of yeast-extracts that have been exposed to ultra-violet light.

TABLE V

FOODS RICH IN IRON

(For daily requirements of iron, see Table I)

The figures given below indicate the number of *milligrams of iron present in 100 grams of edible material.*

PLANT PRODUCTS	
Yeast	20
Coriander, seed	18
Mustard, seed	18
Turmeric, root, dry	18
Sesame (gingelly), seed	15
Fenugreek, seed	14
Cocoa, powder	14
Tamarind	11
Job's Tears (adlay)	10
Grams	4–9
Kidney Bean	8
Sorghum	7
Soya Bean	7

PLANT PRODUCTS (*cont.*)	
Lentils (red dhall)	7
Molasses	7
Betel leaves	6
Wheat	3–5
Maize	5
Millet	5
Oatmeal	5

ANIMAL PRODUCTS	
Liver	10
Kidney	10
Heart	8
Shellfish	5

TABLE VI

FOODS RICH IN CALCIUM

(For daily requirements of calcium, see Table I)

The figures given below indicate the number of *milligrams of calcium present in 100 grams of edible material.*

PLANT PRODUCTS	
Sesame (gingelly), seed	1500
Cumin	1080
Coriander	630
Mustard, seed	490
Millet, finger	350
Soya Bean	220
Grams	140–280
Job's Tears (adlay)	200
Molasses	270
Green Leafy Vegetables	210
Tamarind	170
Betel leaves	150

PLANT PRODUCTS (*cont.*)	
Food Yeast	127
Kidney Bean	110

ANIMAL PRODUCTS	
Milk, powder, skimmed	1200
Milk, powder, whole	900
Milk, condensed	240–290
Milk, cow's, fresh	120
Cheese	850
Eggs	55

NOTE ON PHOSPHORUS REQUIREMENTS

No separate table is given here for foods rich in phosphorus because most of the foods listed opposite as being rich in calcium are also rich in phosphorus. So if the daily calcium requirement is satisfied from these sources it is almost certain that the body will get sufficient phosphorus at the same time. Also, it is better to have an excess of calcium in the diet than to have an excess of phosphorus (for reasons explained on p. 19) and you can ensure that your phosphorus intake will be adequate by looking after your calcium intake.

TABLE VII

FOODS SUPPLYING PROTEIN

In comparing the food-value of protein foods it is necessary to know what proportion is digested and absorbed. The first column shows the total amount of protein as determined by chemical analysis; the second column shows what percentage of this protein is available to the body after digestion†; the third column shows what percentage of the original food actually supplies protein to the body.

	Total protein present in food (per cent.) (*a*)	Relative availability (per cent.) (*b*)	Percentage actually available $\frac{(a \times b)}{100}$
Soya Bean	43	54	23
Beef (lean)	22	98	22
Peanuts (roast) . . .	32	56	18
Peanuts (raw) . . .	28	58	16
Pulses (dried) . . .	26	50	13
Eggs	12	94	12
Rice (brown) . . .	11	80	9
Rice (white)	6	80	5
Wheat Flour	11	67	7
Maize (whole) . . .	11	60	7

Notice (*a*) that the animal proteins in the above list are almost completely utilized by the body; (*b*) that the vegetable proteins are of much lower biological value, weight for weight; (*c*) that the protein in rice is of higher biological value than that of other cereals; (*d*) the very high value of the soya bean as a protein food.

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† i.e. the *biological quality* of each particular protein.

TABLE VIII

AVERAGE COMPOSITION OF MILK OF VARIOUS MAMMALS

Animal	Water (per cent.)	Fat (per cent.)	Milk Sugar (per cent.)	Protein (per cent.)	Mineral matter (per cent.)
Human Females . . .	87·6	3·8	6·4	2·0	0·3
Cow (European) . . .	87·4	3·8	4·8	3·4	0·8
Cow (Indian) . . .	86·7	4·3	4·7	3·7	0·8
Buffalo	82·2	7·7	4·8	4·4	0·9
Goat	86·9	4·1	4·6	3·8	0·9
Sheep	83·6	6·2	4·2	5·2	1·0
Ass	90·1	1·4	6·2	1·9	0·5
Elephant	79·3	9·1	9·0	2·5	0·5

APPENDIX B

NOTE ON THE EFFECTS OF ALCOHOL UPON THE HUMAN BODY

The effects of alcohol* upon the body have been summarized by a British Royal Commission as follows:

(1) Alcohol is primarily a *drug* acting directly on the nerve centres.

(2) Alcohol is *not* a stimulant, but it is essentially a *narcotic* (i.e. it brings about sleepiness or even unconsciousness).

(3) When taken in excess, alcohol acts as a *poison* (like any other drug); and if taken habitually in excess alcohol may cause, or help to cause, a variety of diseases.

(4) The drug or poison action of alcohol is considerably reduced when it is taken in dilute solution or with food.

(5) Alcohol has some food, or fuel, value but any such value is largely offset by the disadvantages of its drug action.

(6) The use of alcohol as an aid to work, whether physical or mental, is scientifically unsound.

(7) Alcohol has no value for preventing or curing disease (although within a strictly limited range of conditions and under medical supervision it has a place in medical treatment).

GLOSSARY

Simple definitions of general words in the text which are not included in the standard vocabulary on which this General Science Course is based, and of other words which were not used in Books I and II.

Scientific words whose meaning is explained in the text are listed in the Index.

abattoir, place built for the killing of animals for food.
abnormal, not normal.
abscess, collection of *pus* formed in a cavity in the body-*tissues*.
abundant, plentiful.
accessory, additional.
achieve, reach, gain something aimed at.
acquire, gain by oneself and for oneself.
adequate, sufficient for requirements.
adjust, fit one part to another; change slightly.
adult, grown-up person.
aid, help.
alcohol, spirit of wine.
alter, change.
alternative, choice between two (or more) things.
amazing, astonishing.
ambulance, car for carrying sick or wounded persons.
ancestor, any one of those persons from whom one's father or mother is descended.
ankle, joint connecting foot with leg.
anti-, against, opposite.
antiseptic, substance that stops the growth of bacteria.
appetizing, causing desire to eat; (*n.*), *appetite*.
appreciate, set high value on.
aspect, way a thing presents itself to the eye or the mind.
athlete, one who competes or excels in physical exercises.
auger, tool with screw-point for *boring* deep holes.
available, able to be used, within one's reach.

balloon, air-tight bag usually filled with a gas which is lighter than air.
bandage, long white cloth for covering a wound; also (*v.*) apply a bandage.
barracks, building for housing soldiers.
benefit (*n.*), advantage.
benign, (of illness) not of a dangerous type.
biology, science of life of animals and plants.
biscuit, small thin cake made chiefly of flour and water and baked hard.
bleach, whiten by exposure to sunlight or certain chemicals.
blister, a watery swelling under the skin caused by burns, rubbing, &c.
boil (medical), hard swelling of the skin, larger than a *pimple* and filled with *pus*.
bookworm, one who is too fond of reading.
bore (*n.*), internal diameter of tube or pipe; its *calibre*.
bowel, any part of food-canal below stomach.
breed (*v.*), have young ones, reproduce.
breeze, gentle wind.
bristle, short stiff hair of pig and some other mammals.
brittle, hard but easily broken.

bruise (*n.*), flesh injury and discoloration caused by blow or pressure without the skin being broken.
bucket, container for carrying water by hand.
bulk, size or mass or volume.

calf (animal), young cow or bull.
calibre, see *bore* (*n.*).
calorie (or *gram-calorie*), the scientific unit of heat *energy*; 1 *kilo-calorie* = 1,000 *gram-calories*.
calorific value, ability to produce heat-*energy*.
calorimeter, vessel in which heat-measurements are made.
cane (*n.*), hollow woody stem, e.g. thin bamboo.
capable, able.
capacity, holding-power, receiving-power, volume, ability.
capillary (*adj.* and *n.*), very fine, hair-like (tube or blood-vessel).
cement—concrete, building material used as a wet paste which hardens into rock-like solid.
cereal, eatable kind of grain, e.g. rice, millet, wheat, barley.
chamber, enclosed space in body of animal or plant; (a) room.
charcoal, black porous residue left after heating wood in absence of air.
chemical (*n.*), any substance obtained by, or used in, *chemistry*; (*adj.*), of or made by chemistry.
chemistry, science treating behaviour of elements in their various combinations.
chew, work food about between the teeth in order to crush it.
chill (*v.*), make cold.
chipped, with broken edges.
choke (*v*), be unable to breathe because of something in windpipe *or* stop the breathing by pressing or filling the windpipe.
circumstances, *external* conditions.
claw, pointed nail of bird's or beast's foot.
clinic, part of hospital where advice and treatment are given (usually free).
clot, (form into) half-solid lump(s) (of blood, cream, &c.).
clump (together), form close group or *cluster*.
cluster (*v.*), form close group of like things.
collapse, sudden failure or breakdown.
combustion, burning.
communal, belonging equally to all the people living in one district and having common interests, i.e. belonging to the *community*.
communicable, able to be passed on or *communicated*.
compartment, *chamber*.
compel, force (to do something).
compound, enclosure in which house or factory stands.
compulsory, enforced, *compelled*.
concave, curving inwards; opposite of *convex*.
conservation, preservation.
consult, ask for guidance or opinion.
consumer, user of product.
contaminated, made impure, *infected*.
contrast, marked difference.
converge (of two or more), move towards a point from different directions.
convex, curving outwards; opposite of *concave*.
convey, transport or transmit.
co-operation, working together for one purpose; *team*-work.
co-ordination, the act of bringing into proper relation.
create, make; bring into existence.
crop, (here) bag-like enlargement of *gullet* in birds, insects, &c., where food is prepared for *digestion*.
crumbly, easily broken into *crumbs* (like dry bread).
crust, hard, dry formation on the skin; *also* hard outer part of bread.

culture, a cultivation of bacteria.
curd, *clot* of substance formed, e.g. when milk goes sour.

dairy, place where milk is dealt with, milk-shop.
defect (*n.*), failing.
deficiency, want, lack.
deliberate, intentional, done on purpose.
dense, closely packed.
dental, of the teeth.
dentist, tooth-doctor.
derive (from), have as starting-point.
desiccation, removal of all water from something, drying up.
detect, discover the presence or nature of.
determine, find out or fix accurately.
devote, set aside entirely for one purpose.
diet (*n.*), habitual food, feeding-plan.
digest, change food in the body so that it can be absorbed; *digestive*, concerning or helping digestion.
disinfectant, substance which destroys germs and makes free from *infection.*
disorder (medical), *abnormal* action or working.
dispensary, place where *dispenser* makes up and gives out medicines.
dispose, put away, get rid of; (*n.*), *disposal.*
distribute, put out at different points; spread out.
diverge, move in different directions spreading out from a point (opp., *converge*).
donor, giver.
dose, amount of medicine to be taken at one time.
dough, flour *moistened* and *kneaded.*
draught, current of air between openings in room, &c.
droplet, a very tiny drop.
drug (*n.*), medicinal substance.
duct, fine tube in the body carrying liquid.
dump (*n.*), heap of useless earth, &c.; (*v.*), deposit this.
duration, time thing lasts.
dwarf, person, animal, or plant much below normal size (opp., *giant*).
dye (*n.*), colouring-matter that can be taken up and held by materials, changing their colour permanently.
dynamite, a powerful explosive substance.

edible, fit to be eaten.
effective, producing desired effect.
elbow, outer part of middle joint of arm; corner or bend shaped like elbow.
embed, fix in surrounding material.
embryo, young, partly-developed plant or animal.
emerge, come into view.
emotion, *mental* feeling, state of mind.
energy, a body's power of doing work by moving, &c.; capacity for work.
engage, employ.
enormous, very large.
environment, surrounding objects or conditions.
epidemic, disease which is widespread for a time.
establish (*v.*), set up, decide, place beyond question.
evacuate, empty out.
exclude, shut out.
excreta, *faeces* and *urine.*
excrete (*v.*), pass out from body-system.
expert (*adj.*), practised, skilful; (*n.*), person *expert* in subject.
expire, breathe out (opp., *inspire*).
external, outside (opp., *internal*).
extravagant, beyond reason, wild; wasteful.

faeces, solid food-waste from animal's body, droppings.
famine, extreme scarcity of food.
fatal, ending in death.
fatigue, tirerdness.
feature, characteristic part.

fermentation, process like that produced by *yeast* in *dough*, or by yeast in sugary liquids (producing *alcohol*).
filth, disgusting dirt.
finally, as the last result or act.
flexible, that will bend without breaking.
flush, (of blood) rush into blood-vessels of skin.
focus (*n.*), point at which light-rays meet after reflection from a curved *mirror* or after being bent by passing through a *lens*; (*v.*), *converge* to a *focus*.
foil (*n.*), metal rolled out into very thin sheet.
fore, in front; front part.
foul, dirty, unhealthy, bad-smelling.
fracture (*n.*), breakage (usually of bone).
fry, cook in boiling fat.
function, special activity or purpose of a person or thing; action by which anything carries out its purpose.
fundamental, forming a foundation, essential.
funds, supplies of money.
fungi, flowerless, non-green plants; (singular, *fungus*).

galvanized iron, iron coated with zinc.
garment, article of clothing.
gauze, thin, almost transparent, woven material of cotton, wire, &c.
generation, all persons born about the same time; average time in which children are ready to replace parents (about 30 yrs.).
germicide (*n.*), substance that kills germs.
giant, unusually tall and big person, animal or plant (opp., *dwarf*).
gland, kind of organ forming, holding and giving out, e.g., digestive juices, milk, &c.
glove, hand-covering.
gnaw, bite repeatedly, as a mouse does.
gravel, coarse sand and small stones.
gravity, attractive force by which a body is drawn towards the centre of the earth.
gravy, juices that flow out from meat during cooking; food dressing made from these juices.
graze, (of cattle) feed on grass; (of skin) scrape skin in rubbing past rough object or material.
gum (dental), firm flesh in which the teeth stand.
gut, food-canal below the stomach; the *intestines*.

handicap (*n.*), disadvantage; (*v.*), place (person) at disadvantage.
harbour (*v.*), give shelter to.
hatch, break or come out of an egg.
hawker, person that carries around articles for sale from house to house.
hobby, favourite subject or occupation which is not one's main business.
host, one who entertains a guest; animal or plant *harbouring parasites*.
humidity, dampness.
husk, hard outer covering of seed, &c.
hygiene, the science of health.

ignorant, lacking knowledge.
image, (here) likeness of an object's *external* form produced by mirror or lens.
immune, protected against, unaffected by.
impulse, driving-power, *stimulus*.
incinerator, enclosed fire-place for burning rubbish.
infant, (here) child under seven years of age.
infect, (of person) give disease to; (of things) able to give disease by having been in touch with diseased person.
inferior, of poor quality; situated below (opp., *superior*).
infested, over-run by, crowded with.
inhabit, live in.
inject, force (liquid) into a cavity.
injure, do harm to.
inorganic, (of minerals) not organic.

insanitary, not healthy, especially with regard to dirt and *infection*.

insecticide, substance that kills insects.

inspect, look closely into; (*n.*), *inspection*.

inspire, breathe in (opp., *expire*).

instinct, natural tendency to behave in a certain way without reasoning.

insulate, cut off from outside influence (usually from heat exchange or from electrical effects); *isolate*.

intermediate, situated or coming between (in time, space, degree, &c.).

internal, of or in the inside (opp., *external*).

intoxicated, overcome by strong drink containing alcohol.

investigate, inquire into, examine.

involved, being concerned with or included in something.

irrigation, supplying crops with water through pipes or channels.

irritation, uneasy sensation caused by *stimulus*.

isolate, place apart or alone, or in *quarantine*.

itch (*v.* and *n.*), (have) uneasy sensation in the skin causing desire to scratch.

jelly, an elastic, non-*rigid* solid.

jerk (*n.*), sharp sudden pull, twist, or throw.

job, piece of work.

junction, joining-point, joint.

jungle, thick tropical forest.

knead, mix flour and water by working with the hands to form *dough*.

lactate (*v.*), produce milk from milk-*glands*.

larva, pl. *larvae*, insect, from time of leaving egg until it becomes a *pupa*.

laterite, product from weathering of granite rock in wet tropics.

leak (*n.*), hole or passage through which *fluid* wrongly makes its way out; (*v.*), pass out through *leak*.

liable (to), exposed to, open to.

litre, unit of *capacity* in Metric System, about 1¾ pints.

maggot, fly-*larva*.

major (*adj.*), of the greater, more important kind (opp., *minor*).

majority, the greater number, more than half (opp., *minority*).

malignant, (of illness) of a dangerous type (opp., *benign*).

mangrove, tropical tree growing in *swamps*.

manure, animal droppings used as fertilizer.

marshy, continually wet and muddy land.

mat, piece of coarse material laid on floor.

mate (*v.*), pair off for *breeding*.

measure, (here) precaution, planned action to gain object.

mechanism, way a machine works.

membrane, thin flexible sheet of *tissue* lining or connecting parts of body.

mental, of the mind.

mesh, one of the spaces bounded by the threads of a net or by the wires of a *gauze*.

mild, gentle, not severe.

minimum, least possible quantity or size (opp., *maximum*).

miracle, remarkable event.

miraculous, wonderful.

moisten, make slightly wet, make damp; (*n.*), *moisture*; (*adj.*), *moist*.

motion, (here) emptying of the large intestine.

mound, heap of earth.

mucus, sticky fluid.

municipality, town with local self-government; *municipal*, of or carried on by a municipality.

muscle, lean flesh or meat; animal *tissue* that produces movement by contracting.

muzzle, a little cage put over an animal's mouth to prevent it biting, eating, &c.

navy, a country's warships, with their officers and men.
negative, opposite of positive; less than zero; shown by the minus sign −.
nodule, small rounded lump.
nutrition, the feeding process in animals and plants.

obstacle, a bar to progress or success.
obvious, easily seen or understood; plain; clear.
offspring, the young of animals (before and soon after birth).
operating-theatre, special room for *surgical operations*.
organism, a living animal or plant.
oval, egg-shaped.
overlap (*v.*), partly cover; cover and extend beyond.
oxidation, combination with oxygen.

pant (*v.*), breathe quickly and noisily.
paradise, heaven.
paralysed, unable to feel or move owing to failure of nerve-action.
parasite, an animal or plant which lives in or on another *organism* and feeds on it; (*adj.*), *parasitic*.
parboil, half cook by boiling.
partner, one of a pair that shares work or other activity.
passive, acted upon, not active.
paste (*n.*), flour *kneaded* with water, any similar plastic mixture.
pastry, baked flour-paste.
patent-medicine, medicine sold compamercially and *patented* or protected from imitation by other chemists.
tient (*n.*), person who is ill and under a doctor's care.
peat, vegetable matter decomposed by water.
pebble, small water-rounded stone.
period, any length of time.
persistent, continuing to exist or do something in spite of *obstacles*.
petrol, purified *petroleum* used in motor-cars; *gasoline*, *benzine*.
philosopher, a student of *fundamenta* principles, particularly of Nature and the meaning of existence.
pickle (*v.*), preserve in brine or *vinegar*.
pierce, (of sharp-pointed instruments) go into or through; make a hole by doing this.
pit, deep hollow in ground or in skin (e.g. hair-pit).
pitch, black waterproof solid obtained from coal or oil.
platform, level surface raised above surrounding ground.
plug (*n.*), something fitting into and filling a hole; (*v.*), stop with a *plug*.
posture, position of the body.
pound (*v.*), crush to powder.
practical, concerned with action rather than *theory*.
precipitate (*n.*), solid matter thrown down from a solution when suitable chemical reagent is added.
prescribe (medical), advise use of medicine or treatment.
primary, holding first place in importance or in time.
project (*v.*), stand out beyond the surface near-by.
prolong (*v.*), make longer, cause to continue.
pulp, soft part of fruit; any other soft, damp, formless matter.
pulse, each beat of arteries or heart.
pulse (crop), seeds of pod-bearing plant, e.g. peas, beans, lentils.
puncture (*v.*), make small hole in.
pupa, resting-stage in insect's life-history while *larva* is changing into adult insect.
pus, thick yellow matter found in *sore* places.

quarantine, separation (of sick persons, &c.) from others; isolation.

ration, fixed daily allowance of food.
recur (*v.*), come up again, be repeated; (*adj.*), *recurrent*.

refrigerator, apparatus for making and keeping food cold.
refuge (*n.*), shelter from danger; *refugee*, person taking refuge abroad from danger or trouble at home.
refuse (*n.*), rubbish; that which is thrown out as worthless.
registration, official recording.
relapse, fall back into worse state after improvement.
relax, allow to become loose or less stiff.
repel, drive back.
reservoir, place for storing a large quantity of water.
respond, act in answer, make answer or *response*.
restrict, limit.
retain, keep possession of.
revolutionize, completely change or reconstruct.
ridge, line where two sloping surfaces meet, as on top of a roof.
rinse, wash lightly with clean water to clear soap and dirt away.
roam, wander here and there about the country.
roast, cook without water in the heat of an open fire, or in an oven.
rodent, *gnawing* animal.
rug, floor-mat of thick woollen material.

salad, vegetables prepared as food without cooking them.
sandals, shoes with open sides.
sanitation, improving of conditions having an effect on health, particularly removal of dirt and *faeces*.
scalpel, a small sharp knife used in *dissection*.
screen, frame covered with metal netting, &c., for separating liquid from solid, solids of various sizes, &c.
scrub (*v.*), rub hard to clean, especially by applying soap and water with a hard brush.
scrub (*n.*), ground covered with small trees and bushes.
scum, impurities that rise to the surface of liquid.
sediment, solid matter that settles to bottom of liquid.
sedimentation, process during which sediment falls to bottom.
septic (*adj.*), *infected* with harmful germs; not *aseptic*; *sepsis* (*n.*), septic condition.
sewage, *excreta* mixed with waste water and carried in *sewers*.
sewer, covered underground drain carrying *sewage*.
shiver, tremble with cold.
site, ground on which town or building stands or is to be built.
skim (*v.*), take *scum* or cream from surface of liquid.
slab, flat piece of rigid material (e.g. concrete).
sling (*n.*), bandage passing over shoulder to support injured arm or hand.
sluggish, slow-moving.
social, concerned with living in *communities*.
socket, hollow for something to fit into or revolve in.
soot, carbon, black powdery substance, produced by burning coal, &c.
species, class of things with some common characteristics.
splint, piece of wood bound to limb to hold broken bone in proper position while it sets.
spongy, elastic, porous, and absorbent, as a *sponge* used in bathing the body.
spore, single cell from which a new plant or animal can grow.
sprinkle, scatter in small drops or particles.
spurt, burst forth, shoot out, *squirt* out.
sputum, fluid spat out from mouth; *spittle*.
squat (*v.*), sit on one's heels.
squeeze, apply pressure to.
squirt (*v.*), *spurt*.

stall, open-fronted shop.
statistics, numerical facts systematically collected and arranged.
sterilize, make *sterile*, i.e. free from living germs.
stew (*v.*), cook by long gentle boiling in closed vessel with little liquid.
sticking-plaster, cotton or linen material spread with sticky substance and applied to skin to cover wounds or to hold dressings.
stimulate, apply a *stimulus*, act as a *stimulus*.
stimulus, something that causes a *response*.
stink, *foul* smell, disgusting smell.
stoker, man who *stokes* fire under boiler by feeding it with *fuel*.
stool (medical), *faeces*.
stoop, carry one's head and shoulders bowed forward.
strenuous, making or requiring great effort.
subject (*v.*), expose (to).
subsequent, following the event.
subsoil, layer of soil lying immediately under the surface soil.
substitute, put in exchange for.
supervise, oversee, watch or direct the work of.
surgeon, doctor skilled in curing by *surgical* method, i.e. operation or cutting.
symptom, sign of existence of disease or *disorder* in the body.

table-ware, dishes, &c., used at meal-times.
tadpole, *larva* of frog.
talcum, powdered *talc* or soapstone.
tape, narrow strips of cloth.
team, a side of players *co-operating* together.
teat, (here) part of cow's *udder*.
tertian, (fever) which becomes severe every other day.
thatch, roof-covering of straw, grass or leaves.
theoretical, concerned with theory, not practical or experimental.
thorax, part of the trunk between the neck and the belly.
tile, thin piece of baked clay for covering roofs or making floors.
tissue, a mass of cells of the same kind, such as muscle-tissue, nerve-tissue, &c.
toxin, a poison, especially one produced by a germ and causing some particular disease.
trachea, wind-pipe.
tract, part of body performing some special *function*.
transform, make change in form.
transfuse, *inject* blood or other liquid into veins; (*n.*), *transfusion*.
trench, narrow ditch.
type, class or group having common qualities; *typical* (*adj.*), true to type, characteristic.

udder, milk-*gland* of cattle from which milk flows through a *teat*.
ultimate, last of all, final.
urban, of towns.
urine, waste liquid discharged from *bladder*.
utilize, use, make use of.

valve, movable part in vein or tube which controls the flow of liquid or gas.
verandah, open, roofed space along side of house.
vinegar, sour (acid) liquid got from *alcoholic* liquids and used for flavouring and preserving food.
vital, concerned with or essential to life.
vomit, throw out from stomach through mouth.

welfare work, efforts to make life happier for workmen, &c.

yolk, yellow part of egg.

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